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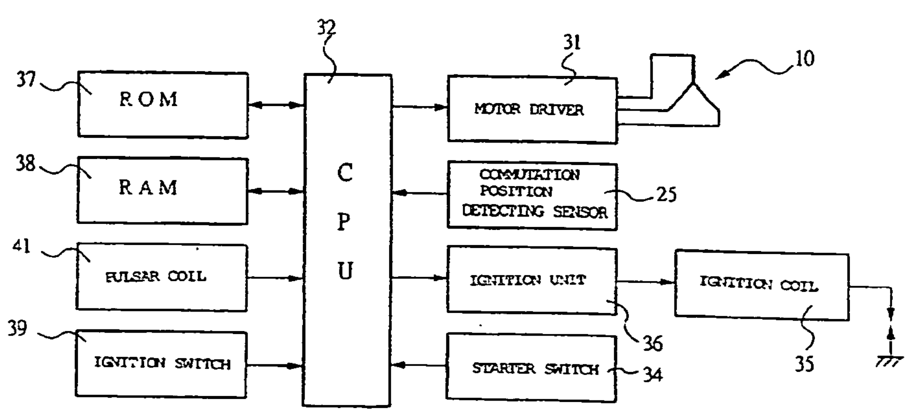
(54) STARTER, START CONTROL DEVICE, AND CRANK ANGLE DETECTOR OF INTERNAL COMBUSTION ENGINE

(57) Realizing a more efficient engine starting control by recognizing an absolute angle of a crank shaft in an engine. An absolute angle of the crank shaft 13 is calculated on the basis of an ignition reference signal of the engine and a commutation position pulse signal of a starter motor 10. and the starter motor 10 is controlled on the basis of the absolute angle. The starter motor 10 is reverse-rotated on the basis of the calculated absolute angle and the crank shaft 13 is temporarily reverse-rotated to an explosion stroke and thereafter is normal-rotated, and thereby the engine is started. Timing from the reverse rotation of the crank shaft 13 to the normal rotation is accurately controlled by the absolute angle, and an efficient inertial starting control can be realized on a engine starting control without waste. Further, it is possible to accurately recognize the absolute angle of the crank shaft 13 in the engine by a crank angle detecting apparatus without increasing the number of the reluctors 40.

FIG. 3



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a starting system for an internal combustion engine and a starting control system for an internal combustion engine, the systems which get starting an internal combustion engine applied to a two-wheeled vehicle, a motor vehicle or the like. Further, the present invention relates to a crank angle detecting apparatus of an internal combustion engine, the apparatus which is applied to a two-wheeled vehicle, a motor vehicle or the like.

2. Description of the Prior Art

[0002] In order to start an engine (an internal combustion engine), that is, in order to get an air-fuel mixture of fuel sucking, compressing and exploding, it is necessary to rotate a crank shaft by an external force until a desired rotation is kept, and then in order to start the engine, there is employed a starting system, that is, a starter using a battery as a drive source.

[0003] In conventional starters, there have been two types, a type in which a rotation of a motor is transmitted to a rotation of a crank shaft via a reduction gear and a type in which the motor is directly connected to the crank shaft. In the type of rotating the crank shaft via the reduction gear, a pinion is engaged with a ring gear provided on an outer periphery of a flywheel of the engine, and the pinion moves forward and backward along a motor shaft, and the pinion gear is engaged with the ring gear at the time of starting so that the speed thereof is reduced and so that a rotational force thereof is transmitted to the crank shaft, and the engagement thereof is canceled after completion of the starting so that they return to respective original positions.

[0004] In general, in the case of stopping the engine, the crank shaft rotates through inertia, and thereafter a compression load in a compression stroke of the engine acts as a brake so that the rotation temporarily stops, and thereafter the crank shaft is a little returned in a reverse direction due to a reaction against a compression and frequently stops near a bottom dead center of the compression stroke. Accordingly, at the time of starting the engine, the rotation of the crank shaft is frequently started from a position that is near the bottom dead center of the compression stroke.

[0005] However, in the case of rotating the crank shaft from this position and cranking the engine, since a load of the compression is applied to the crank shaft immediately after starting of the rotation, it is hard that a rotational speed of the crank shaft is increased and at a position where a reaction force at the time of compression becomes maximum, an electric current close to the electric current flowing at the time of locking is applied to the starter motor. Accordingly, since a torque generated at this time becomes substantially the same torque as the lock torque and gets over a top dead center, it is necessary for the starter motor to have a capacity capable of generating the lock torque equal to or more than the get-over torque.

[0006] In particular, in the case of using as the starter motor an ACG motor of a type that is directly connected to the crank shaft having no speed reduction gear, since it is necessary to generate a great lock torque, there arises a problem that a large-sized and expensive motor must be used. Further, in the case of using a magnet in order to treat a magnetic field, since a strong magnetic field is required and a rotational resistance at the time of operating as the ACG becomes great, there arises a problem that reduction in fuel consumption and reduction in engine power are caused.

[0007] Further, in general, the engine (the internal combustion engine) obtains an engine output by rotating the crank shaft in accordance with a series of strokes comprising the suction, the compression, the ignition, and the explosion of an air-fuel mixture of fuel. In such a series of strokes, in order to control an ignition timing, a valve opening timing and the like, or to monitor the engine rotation number and the like, signals to be used as reference signals thereof are required. In many engines, there has been employed a structure in which pulsar signals are obtained by a signal generating means comprising a pulsar coil and by an iron projecting member called a reluctor, and are used as the reference signals.

[0008] In the engine mentioned above, the reluctor is formed at a predetermined position of a rotational body rotating together with the crank shaft, such as the flywheel, a rotor of a starter motor, and the like. Meanwhile, the pulsar coil is also provided in a side of a stator and is arranged such that the reluctor passes near the pulsar coil. Further, when the reluctor passes near the pulsar coil as the crank shaft rotates, an electric signal is generated in the pulsar coil due to a repulsion caused by the approach of the reluctor to the pulsar coil and thereby a pulsar signal is output.

[0009] In this case, since the pulsar signal is always output at a predetermined crank angle, this pulsar signal is used as an ignition reference signal and an ignition timing control is executed. Further, the reluctor is mainly constituted by one reluctor formed on the rotational body and, in this case, the pulsar signal is output once with respect to one turn of the crank shaft. Accordingly, it is possible to calculate the engine rotation number on the basis of an interval of the pulsar signal, and various kinds of processes such as the control of a fuel injection amount and the like can be executed by using the calculated value.

[0010] In this case, in recent years, as the engine has a high performance, a control aspect thereof becomes complicated, so that it is necessary to monitor even the fluctuation of the rotation number during one turn of the

crank shaft and thereby execute a detailed control corresponding thereto. Therefore, a control with a high performance has been put into practice by increasing the number of the reluctors and by outputting the pulsar signal at a minuter angle interval.

[0011] However, there arise problems that as the number of the reluctors is increased as mentioned above, the number of the processes is increased accordingly, and that the more accurate the control is executed by increasing the number of the reluctors, the more costs pile up.

[0012] An object of the present invention is to realize the starting control of a more efficient engine by recognizing an absolute angle of a crank shaft in an engine. Further, another object of the present invention is to provide a crank angle detecting apparatus capable of accurately recognizing the absolute angle of the crank shaft in the engine without increasing the number of reluctors.

[0013] The above and other objects and novel features of the present invention will be apparent from the description in the present specification and the accompanying drawings.

SUMMARY OF THE INVENTION

[0014] A staring system for an internal combustion engine according to the present invention is characterized by: a starter motor connected to a crank shaft of the internal combustion engine; and a control means for acquiring an absolute angle of the crank shaft on the basis of an ignition reference signal of said internal combustion engine and a rotational pulse signal and controlling said starter motor on the basis of said absolute angle.

[0015] Further, a starting system for an internal combustion engine according to the present invention is characterized by: a starter motor connected to a crank shaft of the internal combustion engine; and a control means for acquiring an absolute angle of the crank shaft on the basis of an ignition reference signal of said internal combustion engine and a commutation position pulse signal of said starter motor and controlling said starter motor on the basis of said absolute angle.

[0016] In accordance with the present invention, the absolute angle of the crank shaft is acquired by using the existing signals such as the ignition reference signal or the commutation position pulse signal, and the starter motor is controlled on the basis of this. Accordingly, it is possible to execute an accurate starting control which employs the absolute angle of the crank shaft without further adding a crank angle sensor or the like, and so to realize the engine starting with good efficiency.

[0017] In this case, said control means may apply a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined position, and thereafter apply a normal current carried, and thereby start said internal combustion engine. By doing so, it is possible to accurately control the timing from the reverse rotation of the crank shaft to the normal rotation, and to execute an inertia starting control with good efficiency, by controlling the engine starting without waste.

[0018] At this time, said normal current carried may be executed by detecting that said crank shaft has reached a predetermine crank angle position, or executed by detecting that said crank shaft has started normal rotation.

[0019] Further, in the case where said internal combustion engine is a 2-stroke engine, one of a reluctor and a pulsar coil for generating a second reference signal in addition to said ignition reference signal may be provided.

[0020] In addition, said control means may recognize, at the time of restarting after said internal combustion stops in a state of a STOP and GO operation of stopping idling at the time of waiting at stoplights or the like and restarting the engine at the time of starting, said absolute angle from at least the time when said internal combustion engine becomes equal to or less than a predetermined rotation number; and said control means may apply a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank position, on the basis of said absolute angle after stopping at the time of restarting said internal combustion engine, and thereafter apply a normal current carried, and thereby start said internal combustion engine.

[0021] Also, said control means may apply, in the case where said internal combustion engine stops after getting over an a compression stroke, a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank position, on the basis of said absolute angle acquired before said internal combustion engine stops, at the time of next starting, and thereafter said control means may apply a normal current carried, and thereby start said internal combustion engine.

[0022] Further, said control means may apply, in the case where said internal combustion engine stops after getting over an a compression stroke, a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank position, on the basis of said absolute angle acquired before said internal combustion engine stops, at the time of next starting, and thereafter said control means may apply a normal current carried, and thereby start said internal combustion engine. By doing so, it is possible to always pass through the position for generating the ignition reference signal at the time of reverse-rotating the crank shaft, and to securely acquire the ignition reference signal.

[0023] In addition, said control means may adjust, on the basis of at least any one of a battery voltage and an engine, a position at which the reverse current carried in said crank shaft is finished and a position at which the normal current carried in said crank shaft is started. By doing so, it is possible to executed the more detailed staring control on the basis of states of the battery and

the engine, and to reduce time required for starting.

[0024] Meanwhile, a starting control system for an internal combustion engine according to the present invention is one that executes a drive control of a starter motor connected to a crank shaft of the internal combustion engine, and the starting control system is characterized by: an ignition reference signal acquiring means for acquiring an ignition reference signal of said internal combustion engine; a commutation position pulse signal acquiring means for acquiring a commutation position pulse signal of said starter motor; an absolute angle calculating means for calculating an absolute angle of said crank shaft on the basis of said ignition reference signal and said commutation position pulse signal; and a motor control instructing means for controlling said starter motor on the basis of said absolute angle calculated.

[0025] Then, in accordance with the control system of the present invention, since the absolute angle of the crank shaft is acquired by using the existing signal such as the ignition reference signal and the commutation position pulse signal and the starter motor is controlled on the basis of this, it is possible to execute an accurate starting control which employs the absolute angle of the crank shaft without further adding a crank angle sensor or the like and it is possible to realize the good efficient engine starting.

[0026] In this case, said motor control instructing means may apply a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank position on the basis of said absolute angle, and detect that said crank shaft has reached a predetermined crank angle position or that said crank shaft has started normal rotation, and thereafter apply a normal current carried.

[0027] Also, said starting control system further comprises a battery voltage detecting means for detecting a battery voltage and an engine temperature detecting means for detecting an engine temperature, and said motor control instructing means may control said starter motor on the basis of said absolute angle and at least any one of said battery voltage and the engine temperature. By doing so, a it is possible to execute the more detailed starting control on the basis of states of the battery and the engine, and to reduce time required for starting.

[0028] Note that the normal rotation mentioned in this case means a regular rotational direction of the engine while the reverse rotation means a rotational direction reverse to the regular rotational direction.

[0029] A crank angle detecting apparatus of an internal combustion engine according to the present invention is one that is started by a brushless starter motor connected to a crank shaft, and the crank angle detecting apparatus is characterized by: a reluctor formed in a rotational body provided in said crank shaft; a reference signal generating means arrange close to said rotational body of rotation and generating an electric signal at a predetermined crank angle when said reluctor passes; a commutation position signal generating means for generating a commutation position signal for controlling said starter motor when said starter motor rotates; an angle pulse forming means for forming an angle pulse having a predetermined period on the basis of said commutation position signal; and a crank angle calculating means for calculating an absolute angle of said crank shaft on the basis of the electric signal from said reference signal generating means and said angle pulse.

[0030] In accordance with the present invention, it is possible to calculate the absolute angle of the crank shaft on the basis of the electric signal from the reference signal generating means and the angle pulse formed from the commutation position signal. Accordingly, it is possible to comprehend the current crank angle without adding a reluctor, a crank angle sensor or the like, and to execute the engine control with high accuracy on the basis of the crank angle. Therefore, it is possible to correspond to the control of the engine with high performance without rising the costs caused by increase in the number of steps required, and increase in the number of parts and the like.

[0031] In this case, said reference signal generating means may output an ignition reference signal for determining ignition timing of said internal combustion engine. By doing so, it is possible to make good use of the existing signals and to prevent the costs from rising.

[0032] Further, said commutation position signal generating means may output a pulse signal having a plurality of phases; said angle pulse forming means forms an angle pulse signal having a predetermined period on the basis of change in said pulse signal having the plurality of phases; and said crank angle calculating means may count said angle pulse after the electric signal is input from said reference signal generating means and thereby calculates the absolute angle of said crank shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

FIG. 1 is a cross-sectional view showing a structure of a starter motor to which an engine starting apparatus corresponding to a first embodiment of the present invention is applied.

FIG. 2 is a front elevational view in which a housing and a cover of the starter motor in FIG. 1 are omitted.

FIG. 3 is a block diagram showing a structure of a control system of the starter motor in FIG. 1.

FIG. 4 is a schematic view showing a structure of a functioning means with respect to a starting control in a CPU applied to a control of the starter motor in FIG. 1.

FIG. 5 is a chart showing an engine starting opera-

tion in the first embodiment of the present invention, in which item (a) shows a starting load in each of strokes, item (b) shows a starting energy, item (c) shows a piston position at the time of a starting operation, item (d) shows a pulse signal from a commutation position detecting sensor, and item (e) shows a cam shaft signal.

FIG. 6 is a flow chart showing steps of an engine starting control in the first embodiment of the present invention.

FIG. 7 is a flow chart showing steps of the engine starting control in the first embodiment in accordance with the present invention.

FIG. 8 is a schematic view showing the relation between a commutation position pulse signal and an ignition reference signal.

FIG. 9 is a chart showing an engine starting operation in an second embodiment of the present invention, in which item (a) shows a starting load in each of strokes, item (b) shows a starting energy, item (c) shows a piston position at the time of a starting operation, item (d) shows a pulse signal from a commutation position detecting sensor, and item (e) shows a cam shaft signal.

FIG. 10 is a flow chart showing steps of an engine starting control in the second embodiment of the present invention.

FIG. 11 is a flow chart showing steps of a preliminary normal rotation process in the second embodiment of the present invention.

FIG. 12 is a table showing an example of a control pattern in a starting control system of the present invention.

FIG. 13 is a schematic view showing a structure of a functioning means with respect to a crank angle detecting process in a CPU.

FIG. 14 is a schematic view showing the relation between a commutation position detecting sensor signal, an angle pulse formed from the commutation position detecting sensor signal, and an ignition reference signal.

FIG. 15 is a schematic view showing the relation between the commutation position detecting sensor signal, the angle pulse and the ignition reference signal in the case of setting an interval of the angle pulse at 60 degrees.

FIG. 16 is a schematic view showing the relation between the commutation position detecting sensor signal, the angle pulse and the ignition reference signal in the case of setting an interval of the angle pulse at about 10 degrees.

FIG. 17 is a schematic view in which item (a) shows the case of dividing the angle pulse at a 5-degrees interval, item (b) shows the case of dividing the angle pulse at a 15-degrees interval, and item (c) shows the case of adjusting the angle pulse interval by taking into consideration a CPU load in a high rotation area.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0034] Description will be in detail and below made of embodiments of the present invention with reference to the accompanying drawings.

(First Embodiment)

[0035] FIG. 1 is a cross sectional view showing a structure of a starter motor to which an engine starting system corresponding to a first embodiment of the present invention is applied. FIG. 2 is a front elevational view in which a housing and a cover of the starter motor in FIG. 1 are omitted. FIG. 3 is a block diagram showing a structure of a control system of the starter motor in FIG. 1.

[0036] A starter motor (hereinafter referred to a motor simply) 10 shown in FIG. 1 is directly connected to a 4-cycle engine for a two-wheeled vehicle, and is provided with a stator 12 fixed to an engine case 11 of an engine and a rotor (a rotational body) 14 connected to a crank shaft 13 of the engine.

[0037] The rotor 14 is provided with a yoke 15 using a magnetic material such as an iron or the like and formed in a short cylindrical shape with one end closed, and a cylindrical boss portion 16 is concentrically integrally provided on an inner surface of a bottom wall of the yoke 15 in a protruding manner. Respective taper surfaces of the boss 16 and the crank shaft 13 are connected to each other in a wedge operation manner so as to be fastened by a set nut 17, thereby the rotor 14 is fixed so as to be integrally rotated with the crank shaft 13. A plurality of permanent magnets 18 for constituting a magnetic pole for a magnetic field are arranged and fixed on an inner circumferential surface of the yoke 15 in a circumferential direction so that adjacent permanent magnets 18 become different in pole.

[0038] The stator 12 of the motor 10 is provided with a core 19 made of a magnetic material such as an iron or the like and formed in a substantially star-shaped and short disc shape. The core 19 is fastened and fixed to a housing 20 arranged and installed on an outer surface of the engine case 11 so as to be concentric with the crank shaft 13, by a bolt 21 used as a fastening means. Further, a cover 26 is mounted to an outer side of the housing 20. The rotor 14 is arranged in an outer side of the stator 12 within the housing 20 so as to surround an outer periphery thereof, and the stator 14 rotates around the stator 12 by driving the crank shaft 13.

[0039] The core 19 is integrally formed by laminating a lot of thin sheets made of a magnetic material such as an iron or the like, and has a core body 22 formed in a donut shape. A plurality of salient poles 23 are radially provided on an outer periphery of the core body 22 in a protruding manner. A stator coil 24 is wound around each of the salient poles 23 so as to form a three-phase wire connection, and the stator coil 24 is connected to a motor driver 31 via a terminal (not shown) by a lead

wire and a wire harness (both not shown). That is, the motor 10 is constructed as a brushless motor driven by the motor driver 31.

[0040] Further, in the motor 10, a plurality of (for example, three) commutation position detecting sensors (commutation position signal generating means) 25 are arranged in the cover 26, and is constructed so as to detect a rotational position of the rotor 14 in response to a magnetism of a sensor magnet 42. An output of the commutation position detecting sensor 25 is supplied to the motor driver 31 via a CPU (a starting control system) 32 mentioned hereinafter, and the motor driver 31 generates a current-carrying signal corresponding to a detected signal from the commutation position detecting sensor 25, and supplies an electric current on the basis of the current-carrying signal to the stator coils 24 to excite, one by one, the stator coil 24 wound around each salient pole 23. When the stator coil 24 is excited one by one, a rotating magnetic field is formed by the stator coil 24. Since the rotating magnetic field affects each permanent magnet 18, the rotor 14 is rotated due to the rotating magnetic field and a rotating force of the rotor 14 is transmitted to the crank shaft 13 via the boss portion 16 of the yoke 15 and the engine is started.

[0041] Further, one reluctor 40 is provided on an outer circumferential surface of the rotor 14 in a protruding manner. Additionally, a pulsar coil (a reference signal generating means) 41 is arranged in a side of the housing 20 in such a manner as to be opposed to the reluctor 40. Then, whenever the crank shaft 13 rotates one turn, the reluctor 40 passes near the pulsar coil 41 once and whenever the reluctor 40 passes through, an electric signal is generated in the pulsar coil 41. Accordingly, the electric signal is generated at the time when the crank shaft 13 reaches a predetermined angle, and, in the above-mentioned engine, the signal which is output like this is used as an ignition reference signal for controlling an ignition timing. That is, the reluctor 40 passes through the pulsar coil 41 immediately before a compression stroke is finished (before a top dead center), and the ignition reference signal is obtained there. In this case, in the 4-cycle engine, since the crank shaft 13 rotates twice at each one stroke, the ignition reference signal is also generated immediately before an exhaust stroke is finished.

[0042] Meanwhile, the motor 10 is, as shown in FIG. 3, driven by the motor driver 31 which is controlled by the CPU (control means) 32. The commutation position detecting sensor 25, the pulsar coil 41 generating the ignition reference signal on the basis of an operation of the crank shaft 13, a starter switch 34 of the engine, and an ignition switch 39 are connected to the CPU 32. Further, an ignition coil 35 for igniting the engine is connected to the CPU 32 via an ignition unit 36. Further, a ROM 37 for storing a motor driver which drives logic and various kinds of control programs relating to an engine control or the like, and a RAM 38 for storing data or the like from the various kinds of sensors and the like are connected thereto. Further, a control signal is supplied to the motor driver 31, the ignition unit 36 and the like on the basis of detected values and signals of the various kinds of sensors such as the commutation position detecting sensor 25, the pulsar coil 41 and the like, thereby controlling the motor 10, the ignition of the engine and the like. In this case, the motor 10 itself, the CPU 32, and the like are driven by power source (not shown) mounted on a vehicle and used as a battery.

[0043] Further, the following functioning means are provided in the CPU 32. FIG. 4 is a schematic view showing a structure of the functioning means relating to the starting control in the CPU 32. The CPU 32 includes an ignition reference signal acquiring means 51 for acquiring the engine ignition reference signal from the pulsar coil 41; a commutation position pulse signal acquiring means 52 for acquiring a commutation position pulse signal of the motor 10 from the commutation position detecting sensor 25; an absolute angle calculating means 53 for calculating an absolute angle of the crank shaft 13 in the manner mentioned below on the basis of the ignition reference signal and the commutation position pulse signal; and a motor control instructing means 54 for controlling the motor 10 on the basis of the absolute angle of the crank shaft 13 calculated in the absolute angle calculating means 53.

[0044] Further, the CPU 32 also includes a battery voltage detecting means 55 for detecting a voltage of a vehicle mounted battery, and an engine temperature detecting means 56 for detecting a temperature of the engine on the basis of a coolant temperature or the like.

[0045] FIG. 5 is a view showing a starting principle in the case of applying the starting system of the present invention to a 4-stroke cycle engine, in which item (a) shows a starting load in each of strokes, item (b) shows a starting energy, item (c) shows a piston position at the time of a starting operation, item (d) shows a pulse signal from the commutation position detecting sensor, and item (e) shows the ignition reference signal.

[0046] This engine has a suction stroke in which the piston moves downward from the top dead center with a suction valve open and with an exhaust valve closed, and thereby an air-fuel mixture is sucked into a cylinder; a compression stroke in which the air-fuel mixture is compressed with both of the suction valve and the exhaust valve closed; a work stroke, that is, an explosion stroke in which the air-fuel mixture is ignited a little before the top dead center where the compression stroke is finished, and the piston is pressed down by a high pressure gas generated due to a combustion with the suction valve and the exhaust valve closed; and an exhaust stroke in which an expanded gas is discharged to the outside with the suction valve closed and with the exhaust valve open, and one period thereof is constituted by two turns of the crank shaft 13, that is, by four strokes.

[0047] At the time of rotating and starting the motor 10 with the engine stopped, values of a load at the time

of starting differ as to which stroke the engine to be started takes, as shown in item (a) of FIG. 5. That is, in the exhaust stroke and the suction stroke, since the piston moves upward and downward with any one of the suction valve and the exhaust valve open, the load for rotating the crank shaft 13 becomes comparatively small. On the contrary, in order to start the engine in the compression stroke, since the piston is ascended with the suction valve and the exhaust valve closed, the load of rotation of the crank shaft 13 is increased and a value thereof becomes maximum a little before the top dead center.

[0048] As mentioned above, ordinarily at the time of stopping the engine, the piston frequently stops at a position close to the bottom dead center in the compression stroke. In the conventional starting system, since the engine is started from this position, the energy as shown by a broken line in FIG. 5 requires being supplied to the crank shaft 13 by the starter motor in order to get over the load in the compression stroke at the time of starting.

[0049] In accordance with the starting system of the present invention, at the time of starting the engine, for example, from a state of stopping at a stop position Pa among a normal stop range P shown in item (c) of FIG. 5, at first the engine is temporarily reverse-rotated so as to pass through the positions of the suction stroke, and the exhaust stroke and the crank shaft 13 is reverse-rotated up to the explosion stroke. In this reverse process, the piston moves in directions opposite to the directions shown by arrows in the item "PISTON POSITION AT ENGINE OPERATION" of FIG. 5. That is, the piston moves toward the top dead center at the position of the suction stroke, and moves toward the bottom dead center at the position of the exhaust stroke, and moves toward the top dead center at the position of the explosion stroke.

[0050] Accordingly, in the explosion stroke, the gas staying within the combustion chamber is compressed due to the reverse rotation with the suction valve and the exhaust valve closed, and a normal rotation energy generated by a reaction against the compression is accumulated within the combustion chamber. A dash-double-dot line in item (b) of FIG. 5 shows an accumulated gas compression energy. In this case, at the time of beginning the starting, it is possible to execute the reverse operation in the same manner as mentioned above not only in the case where the piston is within the normal stop range P but also in the case where the piston is stopped at the positions of the suction stroke and the exhaust stroke and the engine is started from the positions.

[0051] After the crank shaft 13 reverse-rotates, for example, up to a reverse rotating position, that is, up to a normal rotating position Qa among a normal rotation starting range Q of the explosion stroke, the crank shaft 13 is normally rotated by the motor 10. At this time, the normal rotational energy stored due to a compression of the gas within the combustion chamber is discharged to a rotating system of the crank shaft 13 including a flywheel or the like, and the energy discharged due to the reaction against the compression and the rotational energy applied by the motor 10 are added to the rotating system.

[0052] In item (b) of FIG. 5, change in a motor energy applied to the crank shaft 13 by the normally rotating motor 10 is shown by a solid line, and change in an inertia energy accumulated in the rotating system is shown by a dash-single-dot line. The inertia energy is rapidly increased due to the compression reaction caused by discharging the energy of the gas accumulated owing to the compression in the rotating system in an early stage of the normal rotation, and the inertia energy in the rotating system is gradually increased from the explosion stroke toward the compression stroke due to the rotational force of the motor 10. Accordingly, in the compression stroke, a combined energy obtained by the inertia energy thus accumulated in the rotating system and the energy of the motor 10 is applied to the crank shaft 13 as shown by a thick solid line. That is, the crank shaft 13 is driven by the inertia energy discharged in accordance with the reduction in the rotation number and consumed for the compression stroke and by the rotational torque of the motor 10, and a maximum get-over torque T can get over the load in the first compression stroke by a total of a maximum value Ti of the discharge energy of the inertia torque and a maximum value Tm of the motor torque.

[0053] FIGS. 6 and 7 are flow charts showing steps of the engine starting control in accordance with the present invention as mentioned above. In this case, at first, the CPU 32 starts a routine by turning on the ignition switch 39 in step S1, and then the step goes to step S2 and it is judged whether or not the starter switch 34 is turned on. Further, if the starter switch 34 is turned on, the step goes to step S3 and the engine is temporarily reverse-rotated. That is, the engine is reverse-rotated from the stop position Pa shown in FIG. 5 toward the side of the explosion stroke.

[0054] Next, in step S4, it is judged whether or not the ignition reference signal is output while the engine is reverse-rotated. In this case, the ignition reference signal is output once whenever the crank shaft 13 executes one turn as mentioned above. Accordingly, when the engine is reverse-rotated from the stop position Pa shown in FIG. 5, the ignition reference signal is also output at a point entering into the exhaust stroke from the suction stroke, as shown in item (e) of FIG. 5. Further, when the ignition reference signal is obtained in the step S4, the step goes to step S5, and an absolute position of the piston, that is, an absolute angle of the crank shaft is recognized and corrected.

[0055] In this case, in the motor 10, for the purpose of controlling the rotation thereof, the commutation position pulse signal is acquired as shown in FIG. 5. FIG. 8 is a schematic view showing the relation between the

commutation position pulse signal and the ignition reference signal. As shown in FIG. 8, in the motor 10, three-phase commutation sensor signals U, V and W are output from three commutation position detecting sensors 25 equally spaced. Further, the commutation position pulse signal having a predetermined period is formed by catching each of the signals at the time of the starting. In this case, since the ignition reference signal is output by the fact that the reluctor 40 passes through a front portion of the pulsar coil 41, a crank angle capable of obtaining such ignition reference signal is always constant (before the top dead center). Further, the commutation position pulse signal can be also obtained at an interval of a predetermined crank angle. Accordingly, after the ignition reference signal is obtained, if how many times the commutation position pulse signal is input is counted, then the rotation angle from a certain predetermined crank angle can be known, and so it is possible to accurately comprehend the current crank angle.

[0056] After the absolute angle of the crank shaft is thus comprehended, the step goes to step S6, and it is judged whether or not the piston comes to a middle position of the explosion stroke while monitoring the crank angle. Further, when it is recognized that the piston comes to the middle position of the explosion stroke, the step goes to step S7 and the current carried by the reverse rotation is stopped.

[0057] Meanwhile, in the case where the piston does not reach the middle position of the explosion stroke, the step goes to step S8, and it is judged whether or not the piston reaches a reverse compression state. That is, before the middle position of the explosion stroke and during the reverse rotation of the crank shaft, it is judged whether or not the piston is in a state capable of being affected by the compression load. In this case, the judgment of the reverse compression state in step S8 is executed by catching a change amount of crank angle. That is, at first, the period of the commutation position pulse signal is detected, and a value obtained at this time is compared to the value obtained at the preceding time. Further, in the case that a difference therebetween becomes equal to or more than a predetermined value, it is judged that the piston is affected by the compression force and thereby the change amount of crank angle is reduced, and it is determined that the piston reaches the reverse compression state. Note that values of the speed calculated from the period may be compared to one another, and further the values of change in acceleration calculated therefrom may be compared to a predetermined value. In this case, there is an advantage that how to judge change in the pseudo acceleration by the period as mentioned above has been small in load applied to the CPU 32.

[0058] In the case where the reverse compression state is detected in step S8, the step goes to step S7 and the reverse current carried is stopped. On the other hand, in the case where the reverse compression state is not detected, the step goes to step S9, and it is judged whether or not a preset maximum reverse time has passed. Further, in the case where the maximum reverse time has passed, the step goes to step S7 and the reverse current carried is stopped. Meanwhile, in the case where the maximum reverse time has not passed yet, the step goes back to step S6 and the above-mentioned steps are repeated.

[0059] Thus, when the reverse current carried is stopped in step S7, the crank shaft 13 rotates through inertia and is thereafter changed to the normal rotation drive. In the control according to the present invention, this change is judged on the basis of three conditions of the absolute angle, the operation and the time, that is, (1) whether or not the crank shaft is reverse-rotated up to the reverse rotation allowing position (before the compression top dead center), (2) whether or not the crank shaft has already started a normal rotation and (3) whether or not a predetermined time has passed after the current carried is stopped.

[0060] Accordingly, since the absolute angle of the crank shaft has already recognized in step S5, at first, in step S10, it is judged whether or not the crank angle reaches a maximum position allowing the reverse rotation (a reverse rotation allowing position). Further, when the crank angle reaches the reverse rotation allowing position (Qa shown in item (c) of FIG. 5), the step goes to step S11 and the crank shaft 13 is normal-rotated, and a regular starting operation is begun.

[0061] Note that the reverse rotation allowing position mentioned above can be suitably adjusted on the basis of an engine temperature (a water temperature, an air temperature, a unit temperature, a motor temperature or the like) and a battery voltage state. That is, on the basis of the engine temperature and the battery voltage, the reverse rotation allowing position is set so as to generate an optimum get-over torque, and thereby the starting can be achieved for the shortest time in accordance with the then state. For example, similarly to restarting immediately after the engine stops, when the engine is easily started, that is, when the battery voltage is high or when the engine temperature is high, the engine is returned to the exhaust stroke and is normal-rotated therefrom. Also, when the battery voltage is a little low or when the engine is not warmed up, the engine is returned to the explosion stroke and is normally rotated. Further, when the voltage thereof is low or when the engine has a low temperature, the engine is normal-rotated by using the compression reaction force caused in the explosion stroke. Further, when the voltage is further lower and the engine has a further lower temperature, the engine is temporarily normal-rotated and is reverse-rotated by using the reaction force caused in the compression stroke and is started by adding the reaction force caused in the explosion stroke. In addition, under the condition that it is expected that the starting can not be executed even by performing these operations, the starting operation itself is not executed and this is informed to a driver by an alarm lamp or the like.

[0062] On the contrary, in step S10, when it is recognized that the crank angle does not reach the reverse rotation allowing position, the step goes to step S12 and it is judged whether or not the crank shaft 13 has already become the normal rotating state. That is, it is judged whether or not the crank shaft returned by the compression force before reaching the reverse rotation allowing position starts normal rotation. Further, if the crank shaft starts normal rotation, the step goes to step S11 and the normal rotating operation is immediately started.

[0063] Further, in the case that the normal rotation is not detected in step S12, the step goes to step S13 and it is judged whether or not a predetermined current carrying stop time (for example, 100 ms) has passed. That is, a predetermined maximum value is set in an inertia rotating time after the reverse rotation, and, in the case where the time has passed, the step goes to step S11 to start normal rotation even before the crank shaft reaches the normal rotation allowing position. Note that, before the current-carrying stop time has passed, the step goes back to step S10, and the above-mentioned are repeated.

[0064] Thus, in accordance with the starting control of the present invention, since the crank angle can be accurately determined by using the ignition reference signal and the commutation position pulse signal, it is possible to securely execute the control from the reverse rotation to the normal rotation on the basis of the absolute angle of the crank shaft without independently providing with the sensor for particularly detecting the crank angle. Further, since the respective maximum values are set in the reverse current-carrying time and the current-carrying stop time, it is possible to prevent a starting time lug equal to or more than a predetermined time from being generated due to the reverse rotation at the time of starting.

[0065] On the contrary, in the case that the piston stops near the bottom dead center of the exhaust stroke, for example, near a position of Pb shown in item (c) of FIG. 5. not near the bottom dead center of the compression stroke. at the time when the engine stops, it is impossible to obtain the ignition reference signal. That is, in the case where the ignition reference signal is not obtained in step S4, it is impossible to execute the control on the basis of the absolute angle as mentioned above. Such case does not happen frequently as described above. but is not said to happen never so that the above-mentioned control system determines the normal rotation timing on the basis of the judgment of the change in the pseudo acceleration mentioned above at this time.

[0066] Accordingly, if the ignition reference signal is not obtained in step S4, the step goes to step S14 shown in FIG. 7 and it is judged whether or not the position is in the reverse compression state similarly to step S8. And, if the reverse compression state is detected, the step goes to step S15 and the reverse current carried is stopped. Meanwhile, if the piston is not in the reverse compression state, the step goes to step S16 and it is judged whether or not the preset maximum reverse rotating time has passed. And, if the maximum reverse rotating time has passed, the step goes to step S15 and the reverse current carried is stopped. On the other hand, if the maximum reveres rotating time has not passed, the step goes back to step S4 and the above-mentioned steps are repeated.

[0067] When the reverse current carried is stopped in step S15, the crank shaft 13 rotates through inertia. Then, the step goes to step S17 and it is judged whether or not the crank shaft 13 has already become the normal rotating state. That is, it is judged whether or not the crank shaft 13 starts normal rotation because the piston is returned by the compression force. If the crank shaft 13 starts normal rotation, the step goes to step S18 and the normal rotating operation is immediately started.

[0068] Further, if the normal rotation is not detected in step S17, the step goes to step S19 and it is judged whether or not the predetermined current-carrying stop time has passed. Then, in the case where the current-carrying stop time has passed, the step goes to step S18 even before the normal rotation is detected and the normal rotation is started. Note that, before the current-carrying stop time has passed, the step goes back to step S17 and the above-mentioned steps are repeated.

[0069] Then, the motor 10 starts normally rotating in accordance with the operation mentioned above. In this case, since the crank shaft 13 rotates with a low load in the exhaust stroke and the suction stroke, the motor 10 reaches substantially the maximum rotation number close to the rotation number obtained at the time of rotating without load before the piston starts the compression stroke. Accordingly, the crank shaft 13 is also rotated at a possible maximum rotation number by the motor 10 immediately before reaching the compression stroke, and the inertial energy stored in an inertial mass in the rotational system is also in a maximum state and the compression stroke is started.

[0070] Thus, the crank shaft 13 is rotated by the combined energy corresponding to the sum of the inertial energy (a dash-single-dot line) and the motor energy (a solid line) as shown in item (b) of FIG. 4) in the compression stroke. Further, as shown in item (b) of FIG. 4, the motor 10 applies the driving energy thereof to the crank shaft 13 twice at the time of running start and at the time of getting over. Accordingly, in comparison with the conventional motor which gets over a load of the compression stroke by applying the energy thereto once, it is possible to efficiently make good use of the motor energy.

[0071] As described above, since the inertial energy is accumulated after the motor gets over the first compression stroke, the motor can easily get over the load caused in the later compression stroke. Accordingly, the engine is started by sparking with using the ignition coil 35 at a predetermined timing.

[0072] As mentioned above, in accordance with the present invention, the motor 10 temporarily returns the

piston to the side of the explosion stroke prior to the starting of the engine and thereafter starts the engine. Accordingly, it is possible to increase the inertial energy held by the crank shaft 13 until the get-over of the first compression stroke. That is, since a running section of the crank shaft 13 is set and energy accumulated between the running section is employed, it is possible to get over the first compression stroke by small motor torque in comparison with the conventional motor. By doing so, it is possible to achieve miniaturization and lower costs of the motor, and to also reduce power consumption of the motor.

[0073] Further, at the time of returning the piston to the side of the explosion stroke, the absolute position of the piston (the absolute angle of the crank shaft) is comprehended by using the ignition reference signal and the commutation position pulse signal and the reverse rotation stop of the motor 10 and the timing of the normal rotation are controlled on the basis of this. Accordingly, it is possible to accurately execute the control from the reverse rotation to the normal rotation by using the existing sensors without using other sensors such as a cam angle sensor, a crank angle sensor and the like. Further, it is possible to accurately control the timing from the reverse rotation of the crank shaft to the normal rotation on the basis of the absolute angle, and to execute a more efficient inertial starting control.

[0074] Note that although the ignition for getting over the compression stroke has been started on the basis of the starting operation mentioned above, in the case where engine stall is thereafter generated, the control of the reverse rotation and the normal rotation of the motor 10 at the time of next starting is executed on the basis of the acquired absolute angle. By doing so, it is possible to execute the good efficient starting by avoiding waste motion of the motor 10.

[0075] Further, in the case of restarting the engine stopped in a state of a so-called STOP and GO operation, that is, an operation for stopping idling the engine at the time of waiting at stoplights or the like and starting the engine at the time of starting, the absolute angle is recognized at least at the time when the rotation number of the engine becomes equal to or less than the predetermined rotation number, and the reverse rotation and the normal rotation is executed on the basis of the absolute angle at the engine stop in the case of restarting the engine, and thereby the good efficient starting may be executed.

[0076] In addition, it is also possible to acquire the absolute angle on the basis of the commutation pulse of the starter, the rotation pulse including directly the rotation signal of the crank shaft and the ignition reference signal, and to control the engine.

(Second Embodiment)

[0077] Next, as a second embodiment, description will be made of a control aspect in which a preliminary normal rotation is executed prior to the reverse rotation at the time of starting in the first embodiment, and thereby the ignition reference signal is securely acquired.

[0078] And now, in the control aspect in accordance with the first embodiment, when the piston stops at the position of Pb shown in FIG. 5 as mentioned above, since the ignition reference signal is not obtained, the change timing from the reverse rotation to the normal rotation is set in accordance with judgment of the change in the pseudo acceleration as shown in FIG. 7. However, even in the case where the piston stops at the position of Pb, if the piston once passed through the output position of the ignition reference signal, then the ignition reference signal can be obtained and thereby the crank shaft can be controlled on the basis of the absolute angle thereof. Therefore, in this embodiment, a preliminary normal rotation is executed by a driving force of such a level as not to get over the compression stroke before the revere-rotating operation executed in the first embodiment, and the piston is temporarily normal-rotated in a direction of the suction stroke or the compression stroke and thereafter is reverse-rotated, and thereby the ignition reference signal is always output at whatever position the piston stops.

[0079] FIG. 9 is a view showing a starting principle according to an second embodiment, in which item (a) shows a starting load in each of strokes, item (b) shows a starting energy, item (c) shows a piston position at the time of a starting operation, item (d) shows a pulse signal from a commutation position detecting sensor, and item (e) shows an ignition reference signal. Also, FIG. 10 is a flow chart showing a control step thereof.

[0080] As shown in FIG. 10, in this embodiment, at first, in step S20, the ignition switch 39 is turned on and thereby the CPU 32 starts a routine. The step goes to step S21 and it is judged whether or not the starter switch 34 is turned on. Further, when the starter switch 34 is turned on, the step goes to step S22 and a preliminary normal-rotating process for temporarily normal-rotating the engine is executed. FIG. 11 is a flow chart showing steps of a subroutine of the preliminary normal-rotating process.

[0081] In this normal-rotating process, the engine is preliminarily normal-rotated from the stop position of Pa or Pb shown in FIG. 5 toward the side of the compression stroke, and timing for changing to the reverse rotation is determined on the basis of the judgment of the change in the pseudo acceleration mentioned above. That is, at first, in step S41, the motor 10 is preliminarily normal-rotated. The normal-rotating process in this case requires a driving force sufficient to move the piston from the neighborhood of the bottom dead center of the exhaust stroke to the neighborhood of the bottom dead center of the compression stroke, and the motor 10 rotates with a lower output than the motor at the time of the regular normal-rotation starting.

[0082] Next, the step goes to step S42, and it is judged whether or not the piston reaches the normal rotation

compression state. That is, it is judged whether or not the piston entering the compression stroke due to the preliminary normal rotation of the crank shaft reaches such a state as to be affected by the compression load. Note that the judgment of the normal rotation compression state in step S42 is executed by the judgment of the change in the pseudo acceleration mentioned above.

[0083] In the case where the normal rotation compression state is detected in step S42, the step goes to step S43 and the normal current carried is stopped. On the contrary, in the case where the normal compression state is not detected, the step goes to step S44 and it is judged whether or not the preset maximum preliminary normal rotation time has passed. Further, in the case where the maximum preliminary normal rotation time has passed, the step goes to step S43 and the normal current carried is stopped. Meanwhile, in the case where the maximum preliminary normal rotation time has not passed, the step goes back to step S42 and the above-mentioned steps are repeated.

[0084] When the reverse current carried is stopped in step S43, the step finishes the routine shown in FIG. 11 and goes to step S23 shown in FIG. 10 and the reverse-rotating operation is executed. Accordingly, the crank shaft 13 is reverse-rotated, and the ignition reference signal is acquired in step S24. In this case, at the time when the reverse-rotating operation is started in step S23, the piston exists in the compression stroke or near the bottom dead center of the suction stroke. When being driven to the side of the explosion stroke therefrom, the piston always passes through a position for generating the ignition reference signal near the top dead center of the exhaust stroke. That is, even if stopping at a position such as the position of Pb, the piston is temporarily moved to the side of the compression stroke and so passes always through the position for generating the ignition reference signal. Accordingly, the ignition reference signal can be securely acquired in step S24, and thereafter the crank angle can be securely comprehended on the basis of the ignition reference signal and the commutation position pulse signal.

[0085] Further, the step goes to step S25 after the ignition reference signal is acquired, and recognition and correction of the absolute position of the piston, that is, of the absolute angle of the crank shaft are executed. Thereafter, the control from the reverse rotation to the normal rotation is executed in steps S26 to S33 on the basis of the absolute angle. Note that since the control of steps S26 to S33 is the same as that of steps S6 to S13 described in the first embodiment, the details thereof will be omitted.

[0086] As mentioned above, in this embodiment, since the preliminary normal-rotating operation is temporarily executed before the reverse rotating operation, the piston always passes through the position for generating the ignition reference signal during the reverse-rotating operation so that the ignition reference signal is securely acquired and the control capable of accurately recognizing the absolute angle of the crank shaft can be executed.

[0087] Note that, in the case where the piston stops at the position close to the explosion stroke rather than the piston for generating the ignition reference signal similarly to the position of Pb, the ignition reference signal can be acquired twice, but the control of the absolute angle may be executed by using any one thereof. Further, at this time, in the case where the reference signal is obtained, the current carried for the preliminary normal rotation can be stopped immediately then and can change to the reverse rotation.

(Third Embodiment)

[0088] Further, as a third embodiment, description will be made of the case where the present invention is applied to a 2-stroke engine. The motor 10 according to this embodiment is constructed such that since the ignition reference signal is output once whenever the crank shaft 13 rotates once in the case of the 2-stroke engine once igniting at one turn, no reference signal exists in the running section for the inertial starting so that the control mentioned above can not be executed.

[0089] Thereupon, in the 2-stroke engine, the control aspect in accordance with the present invention can be realized by adding a second reluctor so as to generate a signal during a running period for the inertia starting, in addition to the above-mentioned ignition reference signal, and by acquiring a reference signal (a second reference signal) for recognizing the crank angle. In this case, if the additional reluctor is placed at such a position that the reference signal is output during a period from a scavenging stroke to the bottom dead center, the scavenging stroke in which an intake air-fuel mixture does not exist in a cylinder to the bottom dead center, then no influence is given to the combustion operation of the engine even when the ignition is executed on the basis of this signal.

[0090] Note that the reluctor may be placed at positions other than the position mentioned above. However, if so, it is necessary to execute a process of inhibiting the ignition relative to the reference signal that is output. Further, in the case where a plurality of reluctors are arranged in order to more precisely execute the ignition control, the control may be executed on the basis of the signals being output from these reluctors.

[0091] Meanwhile, in place of the addition of the reluctor, a pulsar coil may be added. That is, by locating a second pulsar coil at a position of a non-compression stroke (about BTDC 90 degrees to 270 degrees) in addition to the pulsar coil 41 shown in FIG. 1, two reference signals may be output per one turn of the crank shaft.

[0092] The two pulsar coils described above may have the same structure, and, in this case, in the same manner as the regular pulsar coil 41, the igniting operation can be also executed in accordance with the signal

of the added pulsar coil. The ignition near the bottom dead center of the explosion stroke is not harmful to the engine combustion operation, but an igniting energy will be wasted. Further, the side of the bottom dead center may be judged on the basis of the result of recognizing the absolute position. Then, by reversing a polar character (an order of change in voltage) of the added pulsar coil relative to the regular pulsar coil 41 and by making two signals each have a different form, the CPU 32 may be made to judge the two different signals. Accordingly, it is possible to prevent the ignition from being executed at positions other than the regular ignition position, and to prevent the ignition harmful to the combustion operation from being executed and to further save an energy waste.

(Fourth Embodiment)

[0093] Next, as fourth embodiment, description will be made of a starter motor used in an engine (internal combustion engine) to which a crank angle detecting apparatus is applied. Note that the same reference numerals as the first embodiment are denoted in this embodiment relative to the same members and portions as the first embodiment and so the description thereof will be omitted.

[0094] Since the starter motor in accordance with the fourth embodiment has substantially the same structure as the starter motor shown in FIGS. 1 to 3, the description of FIGS. 1 to 3 will be omitted.

[0095] Further, in the CPU 32, the following functioning means is provided. FIG. 13 is a schematic view showing a structure of the functioning means with respect to a crank angle detecting process in the CPU 32. In the CPU 32, an absolute angle of the crank shaft is calculated on the basis of the ignition reference signal and the angle pulse. Further, the CPU is constituted by an ignition reference signal acquiring means 51 for acquiring the ignition reference signal of the engine from the pulsar coil 41; an angle pulse forming means 152 that acquires a commutation position detecting sensor signal (a commutation position signal) for controlling the motor 10 from the commutation position detecting sensor 25 and that forms an angle pulse mentioned below; a crank angle calculating means 153 for calculating the absolute angle of the crank shaft 13 on the basis of the ignition reference signal and the angle pulse; and a motor control instructing means 154 for controlling the motor 10 on the basis of the absolute angle of the crank shaft 13 calculated by the crank angle calculating means 153.

[0096] Meanwhile, in the above-mentioned motor 10, for the purpose of controlling a rotation thereof, the commutation position detecting sensor signal is acquired as shown in FIG. 14. FIG. 14 is a schematic view showing the relation between the commutation position detecting sensor signal, the angle pulse formed from the commutation position detecting sensor signal, and the ignition reference signal.

[0097] As shown in FIG. 14, in the motor 10, three-phase commutation position detecting sensor signals U, V and W are output from three commutation position detecting sensors 25 spaced equally. Further, the angle pulse having a predetermined period is formed by seizing each of the signals at the time of change therein. In FIG. 14, there is shown a state that the angle pulse having an interval of 20 degrees is being formed on the basis of ascending edges of the three-phase commutation position detecting sensor signals U, V and W.

[0098] In this case, since the reluctor 40 passes in front of the pulsar coil 41 and thereby the ignition reference signal is output, the crank angle at which the ignition reference signal is obtained is always fixed (before the top dead center). That is, the crank angle θ_0 at which the ignition reference signal is output is always fixed. Further, the angle pulse is also formed at an interval (20 degrees in FIG. 14) of the fixed crank angle fixed. Accordingly, after the ignition reference signal is obtained at the crank angle θ_0, if how many times the angle pulse is input is counted, the angle of rotation from the crank angle θ_0 can be known and it is possible to comprehend the current crank angle.

[0099] Accordingly, it is possible to comprehend the crank angle by using one reluctor without adding the number of the reluctor 40, and to execute, by one reluctor, the same control as that in the case where a plurality of reluctors are provided, and to reduce steps required for adding the number of the reluctor and reduce the costs. Further, it is possible to accurately comprehend the crank angle by the existing sensors without using other sensors such as the cam angle sensor, the crank angle sensor or the like, and to suppress increase in the costs.

[0100] Further, on the basis of the absolute angle of the crank angle thus detected, the CPU 32 executes various kinds of engine controls such as an engine starting control, a fuel injection timing control, a fuel injection amount control and the like in addition to the ignition timing control of the engine, in accordance with various kinds of control programs stored in the ROM 37.

[0101] Bu the way, accuracy required for detecting the crank angle can be suitably changed by changing the period of the angle pulse as is known also from FIG. 14. FIGS. 15 and 16 are schematic views showing the relation between the angle pulse and the ignition reference signal in the case where the intervals of the angle pulse are set at 60 degrees and about 10 degrees, respectively.

[0102] In FIG. 15, only one phase (U phase) among the commutation position detecting sensor signals is used, and the angle pulse is formed from the ascending portion thereof, and the interval thereof becomes longer than that of FIG. 14. Accordingly, in FIG. 15, the accuracy itself required for detecting the crank angle becomes lower than the accuracy in FIG. 14, but the load applied to the CPU 32 is reduced much more for this.

Therefore, the control and the like of a generalized engine that does not require so much strict control is effectively executed.

[0103] On the contrary, in FIG. 16, the angle pulse is formed by using both of the ascending portion and the descending portion of each of the three-phase signals from the commutation position detecting sensor 25, and the interval thereof becomes shorter than that of FIG. 14. Accordingly, it is possible to enhance the accuracy required for detecting the crank angle in comparison with the accuracy shown in FIG. 14, and so it is preferable to employ the engine in which the strict control with higher performance is required.

[0104] Note that FIG. 16 shows the case of using a one-polar character detecting type hole IC as the commutation position detecting sensor 25, wherein a duty ratio of Hi becomes greater than 50 % in the one-polar character detecting type hole IC. Accordingly, when the angle pulse is formed by using both of the ascending edge and the descending edge, a pulse having a narrow interval and a pulse having a wide interval are alternately generated. In this case, by requiring a periodic measurement of the angle pulse as an average obtained by moving an even period (for example, 2 periods), it is possible to detect the crank angle in accordance with the period having an equal interval. However, if a both-polar character detecting type hole IC is used as the commutation position detecting sensor 25, it is possible to reduce deviation from the duty ratio as mentioned above.

[0105] Further, it is also possible to suitably process the commutation position detecting sensor signal in the angle pulse forming means 52 of the CPU 32 and thereby achieve the optimization of the angle pulse. Item (a) of FIG. 17 shows an example of dividing and processing the angle pulse physically obtained at change points of the commutation position detecting sensor signal in order to improve the accuracy of the control, and of forming the angle pulse in a place where no physical signal exists.

[0106] In item (a) of FIG. 17, the angle pulse formed at an interval of 10 degrees is divided by using both of the ascending edge and the descending edge, and then the angle pulse at an interval of 5 degrees is formed. By doing so, the angle pulse can be formed at a position not existing in the original angle pulse having the interval of 10 degrees, and so the accuracy for the detection can be further enhanced by the correspondence of a circuit or a software without changing the number of the commutation position detecting sensor 25.

[0107] Meanwhile, it is possible to execute the dividing process at intervals of 1 pulse as described above, and to also form the angle pulse at an interval of 15 degrees as shown in item (b) of FIG. 17, so that, even in this case, it is possible to form the angle pulse at a position not existing in the angle pulse at the original angle pulse having the interval of 10 degrees.

[0108] In addition, in the case where the interval (period) of the angle pulse becomes short in the high rotation range of the engine and where the CPU 32 is beyond an arithmetic processing capacity, as shown in item (c) of FIG. 17, it is also possible to adjust the physically formed angle pulse to a more suitable pulse interval in accordance with the circuit or the software. Note that, in the case of being equal to or more than a predetermined rotation, it is possible to employ the correspondence of the change to a control using only one phase among the commutation position detecting sensor signals, or the like.

[0109] The present invention is not limited to the embodiments mentioned above, and, needless to say, can be variously modified and changed without departing from the gist thereof.

[0110] For example, in the first to third embodiments mentioned above, the description has been made of the engine for the two-wheeled vehicle, but the present invention can be applied to the engine for a four-wheeled vehicle. Further, the present invention can be applied not only to an engine having a single cylinder but also to an engine having a plurality of cylinders. In addition, in the embodiments mentioned above, the description has been made of an example of the motor directly connected to the crank shaft of the engine, but the present invention can be applied not only to the directly connected motor but also to a starter motor of a type of driving the crank shaft via a gear. Further, a kind of the motor is not limited to the outer rotor type as mentioned above, and so the present invention can be also applied to a motor of an inner rotor type.

[0111] Further, the present invention can be applied to a field control motor in which a control magnetic pole constituted by a magnetic body is arranged as a field pole of the motor; a so-called hybrid type motor in which a permanent magnet and the above-mentioned control magnetic pole are alternately arranged; and the like.

[0112] In addition, in the embodiments mentioned above, the operation of "the reverse rotation → the normal rotation" of the motor or the operation of "the normal rotation → the reverse rotation → the normal rotation" is executed after the starter switch 34 is turned on, but it is possible to be suitably selected as to which timing among the time of stopping the engine, the time of turning on the ignition switch, and the time of turning on the starter switch these operations are executed at. FIG. 12 is a table showing patterns of the control, in which a symbol X corresponds to a display indicating that the operation is not executed.

[0113] Further, for example, in the fourth embodiment mentioned above, the description has been made of the structure in which the reluctor is formed in the rotor of the motor, but a position for forming the reluctor is not limited to this and the reluctor may be provided in a rotor independently provided in the crank shaft, a flywheel or the like. Further, in the embodiments mentioned above, the description has been made of the engine for the two-wheeled vehicle, but the present invention can be applied to the engine for the four-wheeled vehicle. Further-

more, the present invention can be also applied not only to the engine having the single cylinder but also to the engine having a plurality of cylinders. In addition, the description has been made of the case that the present invention is applied to the 4-cycle engine, but the present invention can be applied not only to the 4-cycle engine but also to the 2-cycle engine.

[0114] In the starting control system of the internal combustion engine in accordance with the present invention, since the absolute angle of the crank shaft is acquired on the basis of the ignition reference signal and the commutation position pulse signal and the starter motor is controlled on the basis of this absolute angle, the starter motor can be controlled by using the existing signals such as the ignition reference signal and the commutation position pulse signal. Accordingly, the accurate starting control can be executed on the basis of the absolute angle of the crank shaft without independently adding the crank angle sensor or the like, and so the good efficient engine starting can be realized.

[0115] Further, by temporarily reverse-rotating the crank shaft on the basis of the absolute angle and thereafter normal-rotating the crank shaft to start the internal combustion engine, it is possible to accurately control the timing from the reverse rotation to the normal rotation of the crank shaft. Accordingly, it is possible to execute the engine starting control without waste, and it is possible to more effectively execute the inertial starting control.

[0116] Furthermore, the crank shaft may be preliminarily normal-rotated prior to the reverse rotation. By doing so, it is possible to always pass through the position for generating the ignition reference signal at the time of reverse-rotating the crank shaft, and to securely acquire the ignition reference signal.

[0117] In addition, an amount of reverse rotation of the crank shaft may be adjusted on the basis of at least any one of the battery voltage and the engine temperature. By doing so, it is possible to execute a suitable starting control on the basis of the battery state and the engine state, and to reduce time required for the starting.

[0118] Meanwhile, the starting control system of the present invention is provided the ignition reference signal acquiring means; the commutation position pulse signal acquiring means; the absolute angle calculating means for calculating the absolute angle of the crank shaft on the basis of the ignition reference signal and the commutation position pulse signal; and the motor control instructing means for controlling the starter motor on the basis of the calculated absolute angle, and so acquires the absolute angle of the crank shaft by using the existing signal such as the ignition reference signal and the commutation position pulse signal and can control the starter motor on the basis of this. Accordingly, it is possible to execute an accurate starting control on the basis of the absolute angle of the crank shaft without independently adding the crank angle sensor or the like and thereby realize the good efficient engine starting.

[0119] Further, by further providing a battery voltage detecting means and an engine temperature detecting means in the starting control system, the motor control instructing means may control the starter motor on the basis of the absolute angle and at least any one of the battery voltage and the engine temperature. By doing so, it is possible to execute a proper starting control on the basis of states of the battery and the engine, and to reduce time required for the starting.

[0120] Furthermore, the crank angle detecting apparatus of the present invention can detect the absolute angle of the crank shaft by using the electric signal from the pulsar coil and the commutation position detecting sensor signal, and so can comprehend the absolute angle of the crank shaft without adding the reluctor, the crank angle sensor or the like. Accordingly, it is possible to execute the engine control on the basis of the crank angle without increasing the number of steps required for processing and the number of parts, and to correspond to the control of the high performance engine without causing the costs to rising.

[0121] In addition, since the absolute angle of the crank shaft is detected by using the reference pulse and the commutation pulse of the ACG starter, it is possible to execute the precise ignition timing control, the EFI control and the starting control without adding a reluctor (other than the reluctor for the ignition reference) and a crank angle sensor.

INDUSTRIAL APPLICABILITY

[0122] As mentioned above, the present invention is useful for the starting system of the internal combustion engine and the starting control system, the systems which start the internal combustion engine applied to the two-wheeled vehicles, motor vehicles or the like. Further, the present invention is useful for the crank angle detecting apparatus of the internal combustion engine, the apparatus which is applied to the two-wheeled vehicles, the motor vehicles or the like.

Claims

1. A starting system for an internal combustion engine, the starting system comprising:

    a starter motor connected to a crank shaft of the internal combustion engine; and
    a control means for acquiring an absolute angle of the crank shaft on the basis of an ignition reference signal of said internal combustion engine and a rotational pulse signal and controlling said starter motor on the basis of said absolute angle.

2. A starting system for an internal combustion engine,

the starting system comprising:

a starter motor connected to a crank shaft of the internal combustion engine; and
a control means for acquiring an absolute angle of the crank shaft on the basis of an ignition reference signal of said internal combustion engine and a commutation position pulse signal of said starter motor and controlling said starter motor on the basis of said absolute angle.

3. The starting system for an internal combustion engine according to claim 1 or 2, wherein said control means applies a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined position, and thereafter applies a normal current carried, and thereby starts said internal combustion engine.

4. The starting system for an internal combustion engine according to claim 3, wherein said normal current carried is executed by detecting that said crank shaft has reached a predetermine crank angle position.

5. The starting system for an internal combustion engine according to claim 3, wherein said normal current carried is executed by detecting that said crank shaft has started normal rotation.

6. The starting system for an internal combustion engine according to any one of claims 1 to 5, wherein said internal combustion engine is a 2-stroke engine, and one of a reluctor and a pulsar coil for generating a second reference signal in addition to said ignition reference signal is provided.

7. The starting system of an internal combustion engine according to any one of claims 1 to 6, wherein said control means recognizes, at the time of restarting after said internal combustion stops in a state of a STOP and GO operation, said absolute angle from at least the time when said internal combustion engine becomes equal to or less than a predetermined rotation number, and said control means applies a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank position, on the basis of said absolute angle after stopping at the time of restarting said internal combustion engine, and thereafter applies a normal current carried, and thereby starts said internal combustion engine.

8. The starting system for an internal combustion engine according to any one of claims 1 to 7, wherein said control means applies, in the case where said internal combustion engine stops after getting over an a compression stroke, a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank position, on the basis of said absolute angle acquired before said internal combustion engine stops, at the time of next starting, and thereafter said control means applies a normal current carried, and thereby starts said internal combustion engine.

9. The starting system for an internal combustion engine according to any one of claims 1 to 8, wherein said control means preliminarily rotates said crank shaft up to a position in a side of the normal rotation from a position for generating the ignition reference signal prior to said reverse rotation.

10. The starting system for an internal combustion engine according to any one of claims 1 to 9, wherein said control means adjusts, on the basis of at least any one of a battery voltage and an engine, a position at which the reverse current carried in said crank shaft is finished and a position at which the normal current carried in said crank shaft is started.

11. A starting control system of an internal combustion engine, which executes a drive control of a starter motor connected to a crank shaft of the internal combustion engine, the starting control system comprising:

an ignition reference signal acquiring means for acquiring an ignition reference signal of said internal combustion engine;
a commutation position pulse signal acquiring means for acquiring a commutation position pulse signal of said starter motor;
an absolute angle calculating means for calculating an absolute angle of said crank shaft on the basis of said ignition reference signal and said commutation position pulse signal; and
a motor control instructing means for controlling said starter motor on the basis of said absolute angle calculated.

12. The starting control system for an internal combustion engine according to claim 11, wherein said motor control instructing means applies a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank position on the basis of said absolute angle, and detects that said crank shaft has reached a predetermined crank angle position, and thereafter applies a normal current carried.

13. The starting control system for an internal combustion engine according to claim 11 or 12, wherein said motor control instructing means applies a reverse current carried such that said crank shaft is temporarily reverse-rotated up to a predetermined crank

position on the basis of said absolute angle, and detects that said crank shaft has begun normal rotation, and thereafter applies a normal current carried.

14. The starting control system for an internal combustion engine according to any one of claims 11 to 13, wherein said starting control system further comprises a battery voltage detecting means for detecting a battery voltage and an engine temperature detecting means for detecting an engine temperature, and said motor control instructing means controls said starter motor on the basis of said absolute angle and at least any one of said battery voltage and the engine temperature.

15. A crank angle detecting apparatus of an internal combustion engine, which is started by a brushless starter motor connected to a crank shaft, the crank angle detecting apparatus comprising:

    a reluctor formed in a rotational body provided in said crank shaft;
    a reference signal generating means arrange close to said rotational body of rotation and generating an electric signal at a predetermined crank angle when said reluctor passes;
    a commutation position signal generating means for generating a commutation position signal for controlling said starter motor when said starter motor rotates;
    an angle pulse forming means for forming an angle pulse having a predetermined period on the basis of said commutation position signal; and
    a crank angle calculating means for calculating an absolute angle of said crank shaft on the basis of the electric signal from said reference signal generating means and said angle pulse.

16. The crank angle detecting apparatus of an internal combustion engine according to claim 15, wherein said reference signal generating means outputs an ignition reference signal for determining ignition timing of said internal combustion engine.

17. The crank angle detecting apparatus of an internal combustion engine according to claim 15 or 16, wherein said commutation position signal generating means outputs a pulse signal having a plurality of phases; said angle pulse forming means forms an angle pulse signal having a predetermined period on the basis of change in said pulse signal having the plurality of phases; and said crank angle calculating means counts said angle pulse after the electric signal is input from said reference signal generating means and thereby calculates the absolute angle of said crank shaft.

FIG. 1

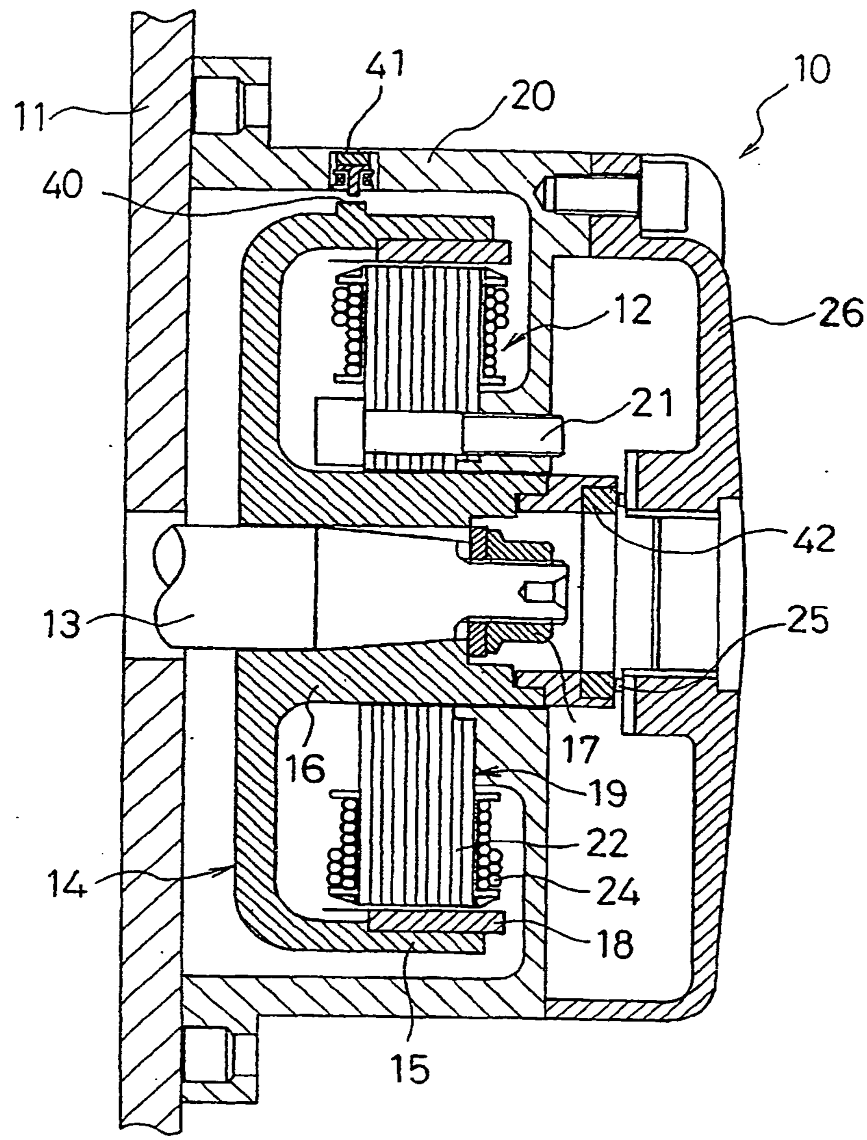


FIG. 2

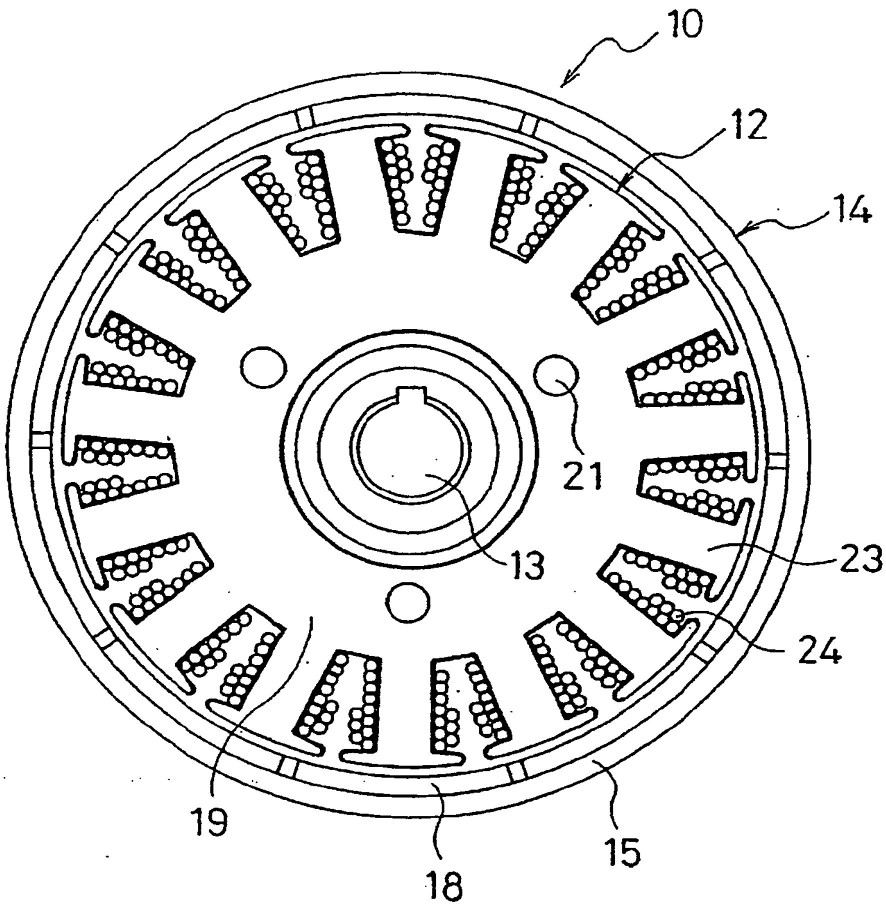


FIG. 3

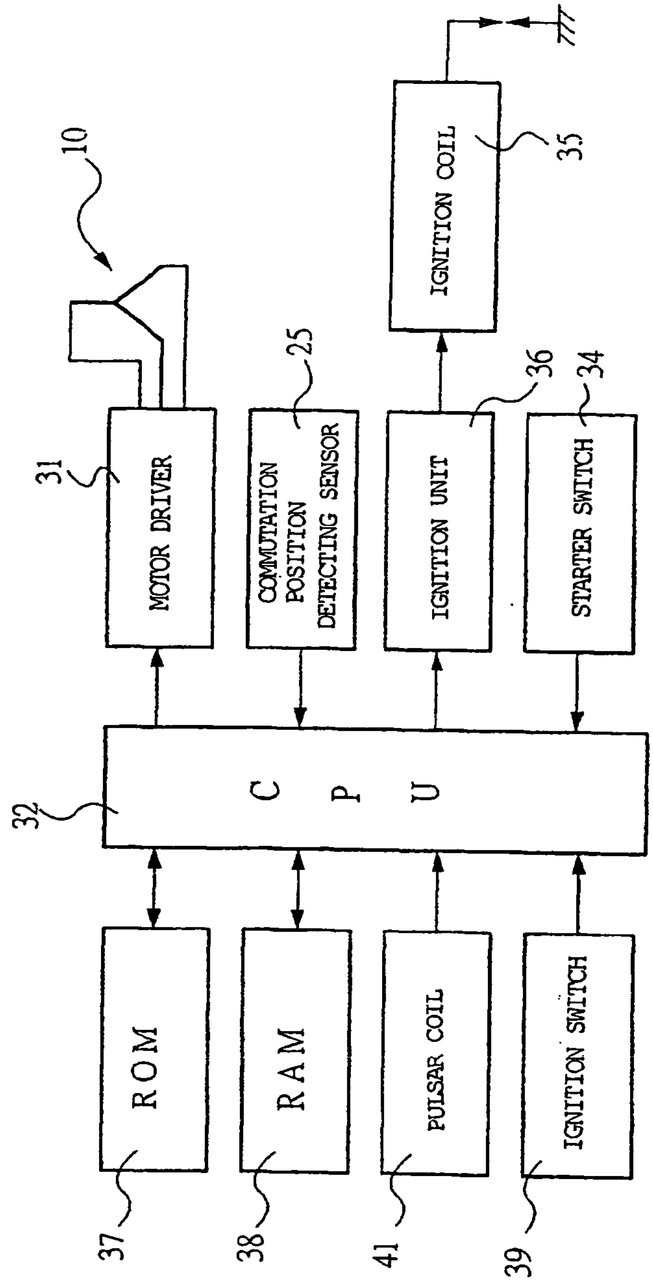

10
31
MOTOR DRIVER
25
COMMUTATION POSITION DETECTING SENSOR
36
IGNITION UNIT
34
STARTER SWITCH
IGNITION COIL
35
32
C P U
ROM
37
RAM
38
PULSAR COIL
41
IGNITION SWITCH
39

FIG. 4

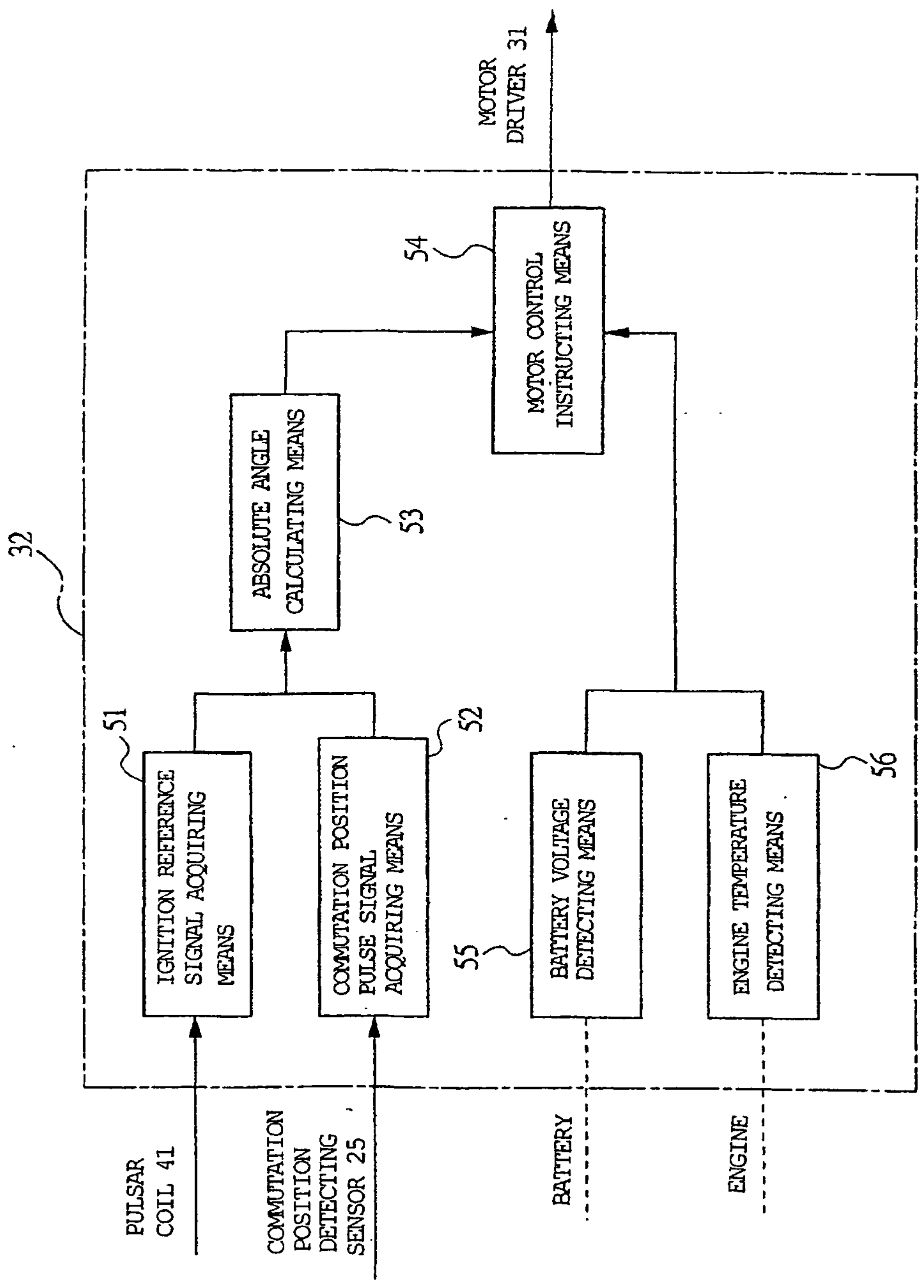

32
51
IGNITION REFERENCE SIGNAL ACQUIRING MEANS
52
COMMUTATION POSITION PULSE SIGNAL ACQUIRING MEANS
53
ABSOLUTE ANGLE CALCULATING MEANS
54
MOTOR CONTROL INSTRUCTING MEANS
55
BATTERY VOLTAGE DETECTING MEANS
56
ENGINE TEMPERATURE DETECTING MEANS
PULSAR COIL 41
COMMUTATION POSITION DETECTING SENSOR 25
BATTERY
ENGINE
MOTOR DRIVER 31

FIG. 5

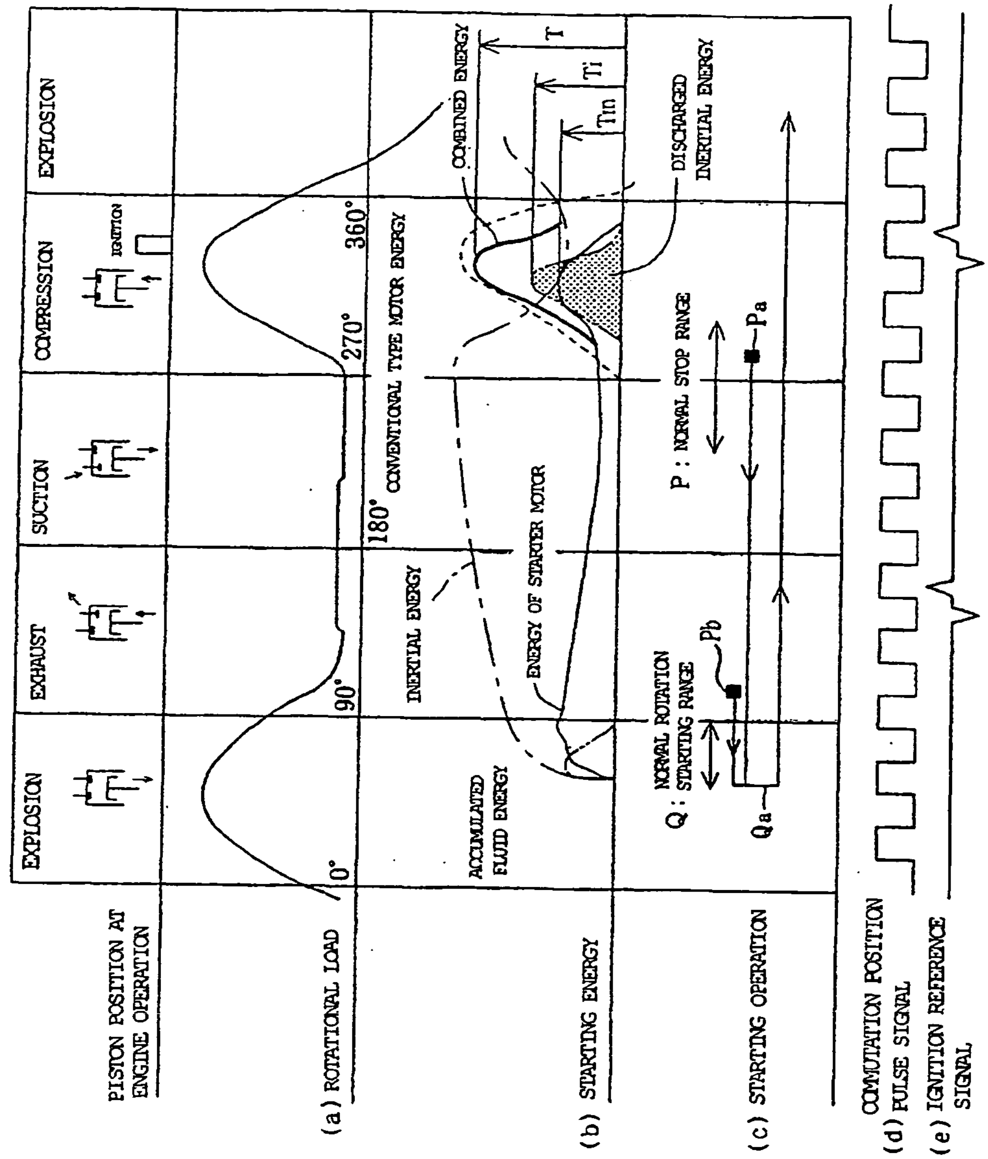

PISTON POSITION AT ENGINE OPERATION
EXPLOSION
EXHAUST
SUCTION
COMPRESSION
EXPLOSION
IGNITION
(a) ROTATIONAL LOAD
0°
90°
180°
270°
360°
CONVENTIONAL TYPE MOTOR ENERGY
(b) STARTING ENERGY
ACCUMULATED FLUID ENERGY
INERTIAL ENERGY
ENERGY OF STARTER MOTOR
COMBINED ENERGY
DISCHARGED INERTIAL ENERGY
T
Ti
Tm
(c) STARTING OPERATION
Q : NORMAL ROTATION STARTING RANGE
P : NORMAL STOP RANGE
Pa
Pb
Qa
(d) COMMUTATION POSITION PULSE SIGNAL
(e) IGNITION REFERENCE SIGNAL

FIG. 6

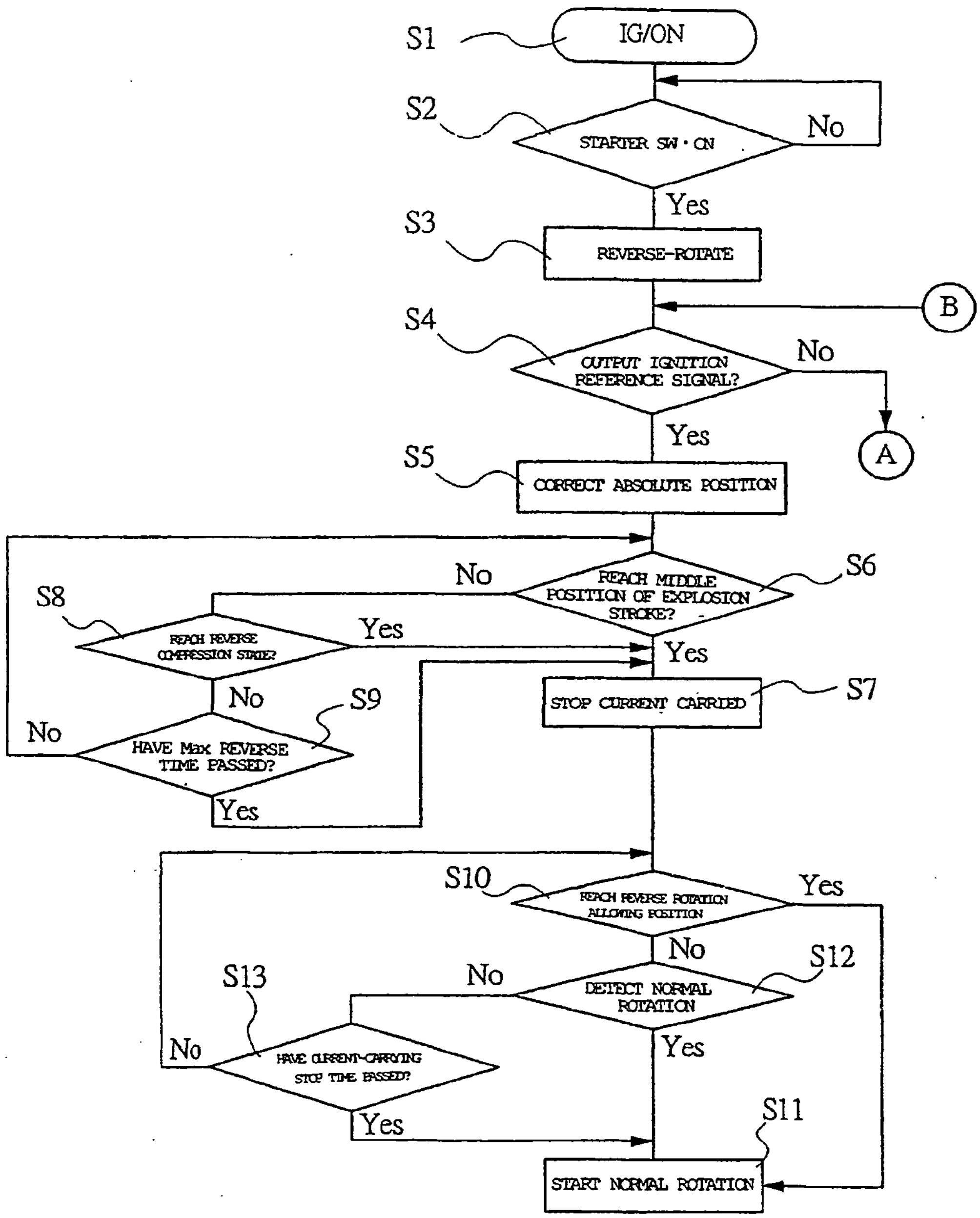

S1
IG/ON
S2
STARTER SW · ON
No
Yes
S3
REVERSE-ROTATE
B
S4
OUTPUT IGNITION REFERENCE SIGNAL?
No
A
Yes
S5
CORRECT ABSOLUTE POSITION
S6
REACH MIDDLE POSITION OF EXPLOSION STROKE?
No
S8
REACH REVERSE COMPRESSION STATE?
Yes
Yes
No
S9
S7
STOP CURRENT CARRIED
No
HAVE Max REVERSE TIME PASSED?
Yes
S10
REACH REVERSE ROTATION ALLOWING POSITION
Yes
No
S12
S13
No
DETECT NORMAL ROTATION
No
HAVE CURRENT-CARRYING STOP TIME PASSED?
Yes
Yes
S11
START NORMAL ROTATION

FIG. 7

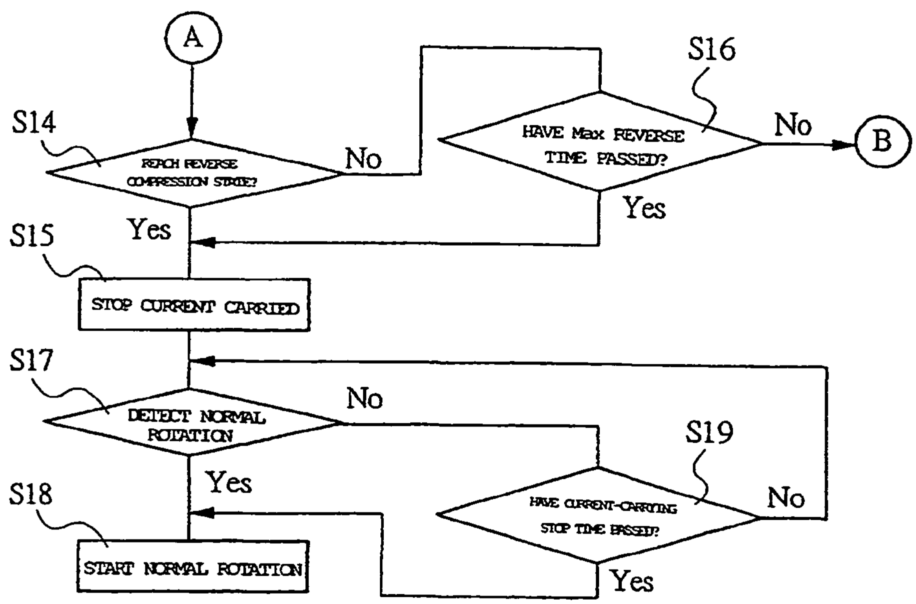

A
S14
REACH REVERSE COMPRESSION STATE?
No
S16
HAVE Max REVERSE TIME PASSED?
No
B
Yes
Yes
S15
STOP CURRENT CARRIED
S17
DETECT NORMAL ROTATION
No
S19
HAVE CURRENT-CARRYING STOP TIME PASSED?
No
Yes
S18
START NORMAL ROTATION
Yes

FIG. 8

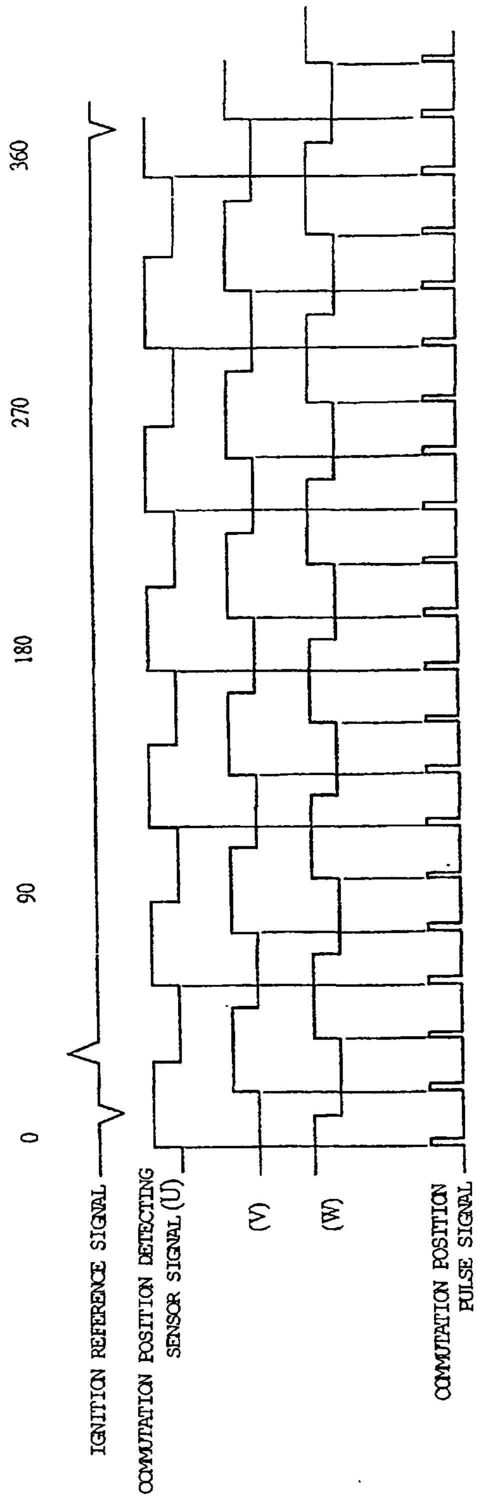

0
90
180
270
360
IGNITION REFERENCE SIGNAL
COMMUTATION POSITION DETECTING SENSOR SIGNAL (U)
(V)
(W)
COMMUTATION POSITION PULSE SIGNAL

FIG. 9

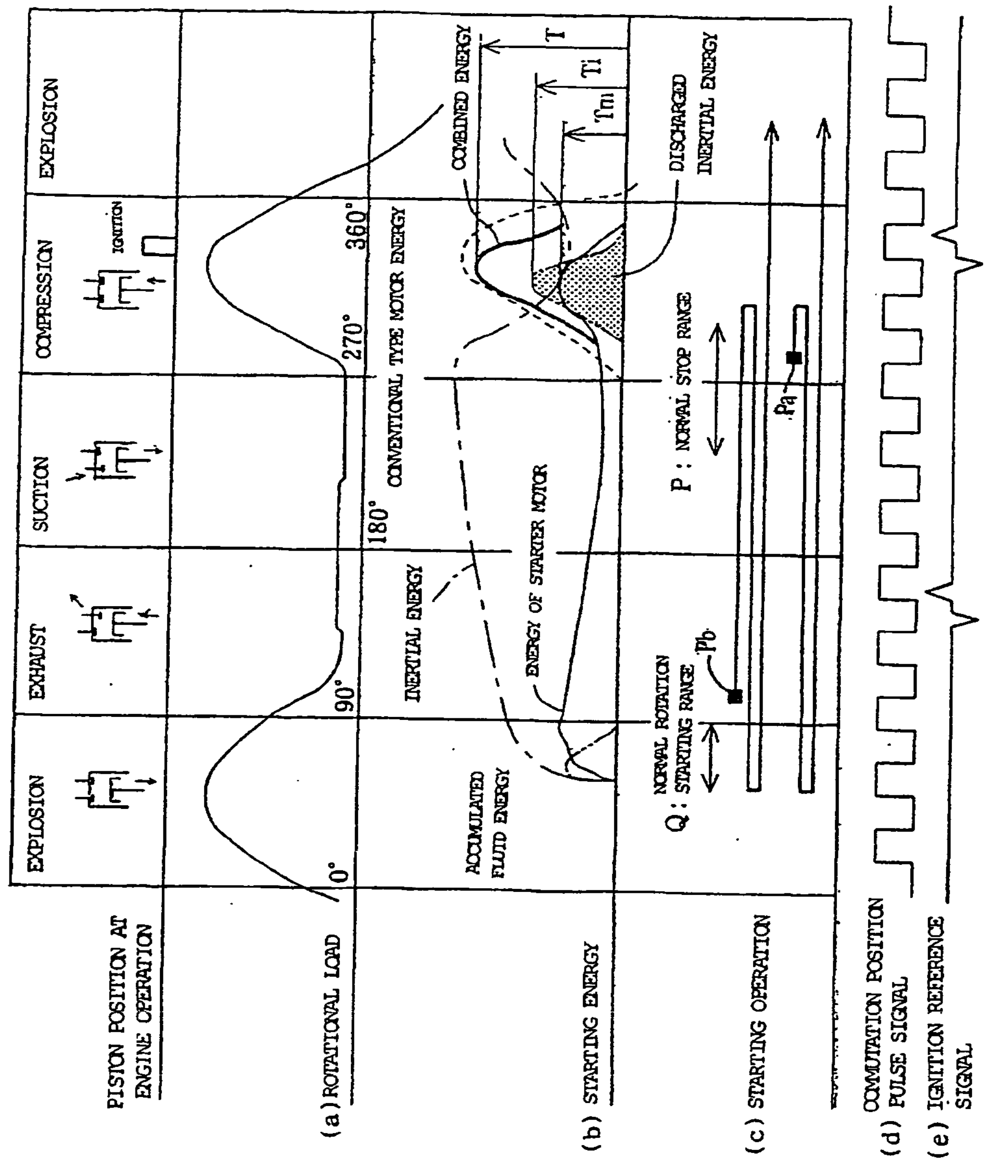

PISTON POSITION AT ENGINE OPERATION
EXPLOSION
EXHAUST
SUCTION
COMPRESSION
EXPLOSION
IGNITION
(a) ROTATIONAL LOAD
0°
90°
180°
270°
360°
(b) STARTING ENERGY
ACCUMULATED FLUID ENERGY
INERTIAL ENERGY
ENERGY OF STARTER MOTOR
CONVENTIONAL TYPE MOTOR ENERGY
COMBINED ENERGY
DISCHARGED INERTIAL ENERGY
T
Ti
Tm
(c) STARTING OPERATION
Q : NORMAL ROTATION STARTING RANGE
P : NORMAL STOP RANGE
Pb
Pa
(d) COMMUTATION POSITION PULSE SIGNAL
(e) IGNITION REFERENCE SIGNAL

FIG. 10

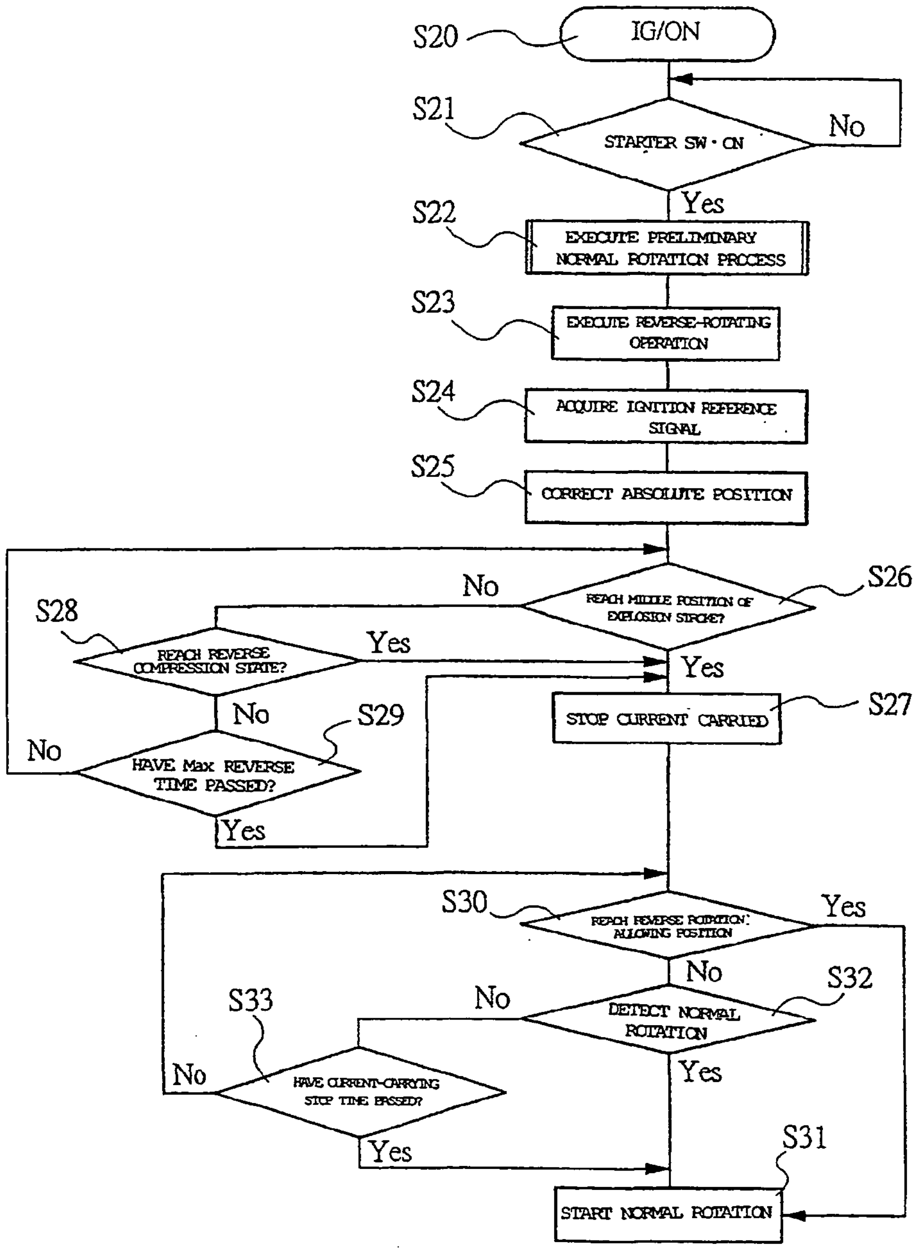

S20
IG/ON
S21
STARTER SW · ON
No
Yes
S22
EXECUTE PRELIMINARY NORMAL ROTATION PROCESS
S23
EXECUTE REVERSE-ROTATING OPERATION
S24
ACQUIRE IGNITION REFERENCE SIGNAL
S25
CORRECT ABSOLUTE POSITION
S26
REACH MIDDLE POSITION OF EXPLOSION STROKE?
No
Yes
S28
REACH REVERSE COMPRESSION STATE?
Yes
No
S29
HAVE Max REVERSE TIME PASSED?
No
Yes
S27
STOP CURRENT CARRIED
S30
REACH REVERSE ROTATION ALLOWING POSITION
Yes
No
S32
DETECT NORMAL ROTATION
No
Yes
S33
HAVE CURRENT-CARRYING STOP TIME PASSED?
No
Yes
S31
START NORMAL ROTATION

FIG. 11

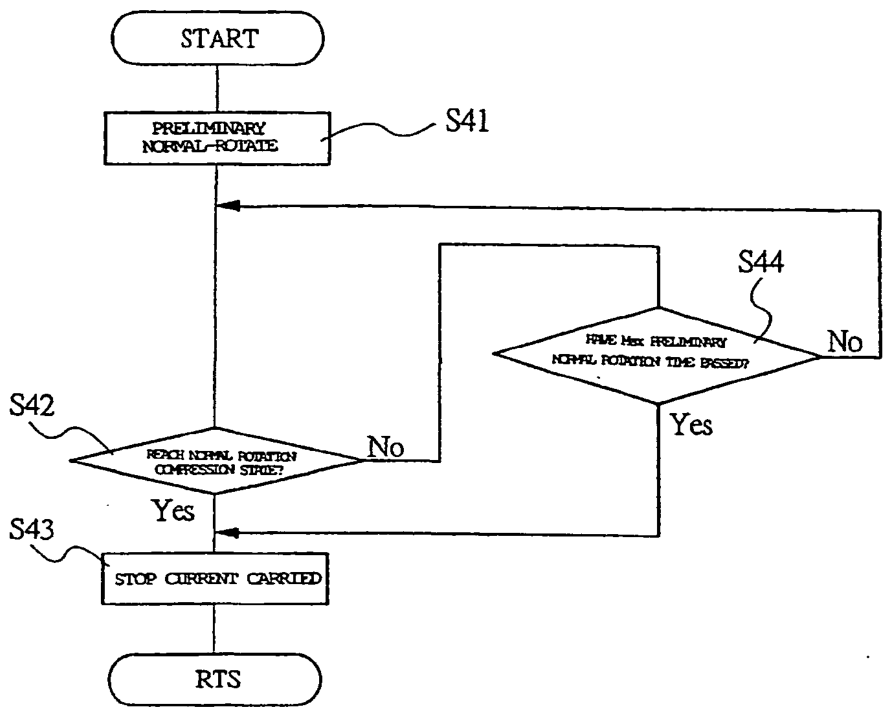

START
PRELIMINARY NORMAL-ROTATE
S41
S42
REACH NORMAL ROTATION COMPRESSION STATE?
No
Yes
S44
HAVE Max PRELIMINARY NORMAL ROTATION TIME PASSED?
No
Yes
S43
STOP CURRENT CARRIED
RTS

FIG. 12

	AT ENGINE STOP	AT IGNITION SWITCH ON	AT STARTER SWITCH ON
REVERSE ROTATION → NORMAL ROTATION	X	X	REVERSE ROTATION →NORMAL ROTATION (1ST EMBODIMENT)
	X	REVERSE ROTATION	NORMAL ROTATION
	REVERSE ROTATION	X	NORMAL ROTATION
NORMAL ROTATION → REVERSE ROTATION → NORMAL ROTATION	X	X	NORMAL ROTATION →REVERSE ROTATION →NORMAL ROTATION (2ND EMODIMENT)
	X	NORMAL ROTATION	REVERSE ROTATION →NORMAL ROTATION
	X	NORMAL ROTATION → REVERSE ROTATION	NORMAL ROTATION
	NORMAL ROTATION	REVERSE ROTATION	NORMAL ROTATION
	NORMAL ROTATION	X	REVERSE ROTATION →NORMAL ROTATION
	NORMAL ROTATION →REVERSE ROTATION	X	NORMAL ROTATION

FIG. 13

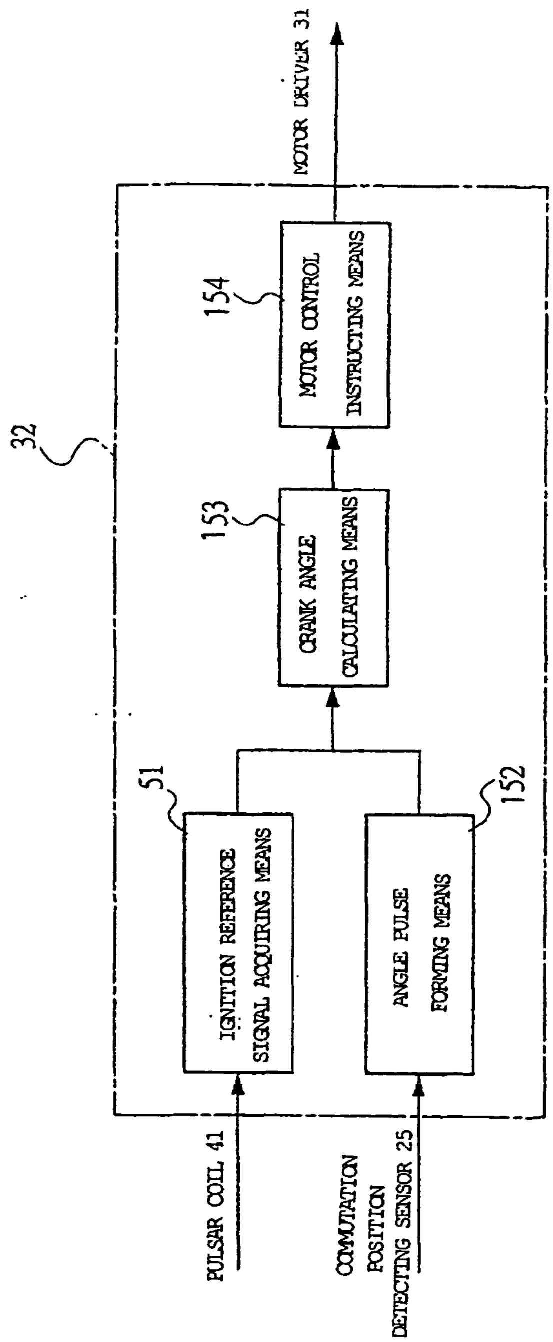

MOTOR DRIVER 31
154
MOTOR CONTROL INSTRUCTING MEANS
32
153
CRANK ANGLE CALCULATING MEANS
51
IGNITION REFERENCE SIGNAL ACQUIRING MEANS
152
ANGLE PULSE FORMING MEANS
PULSAR COIL 41
COMMUTATION POSITION DETECTING SENSOR 25

FIG. 14

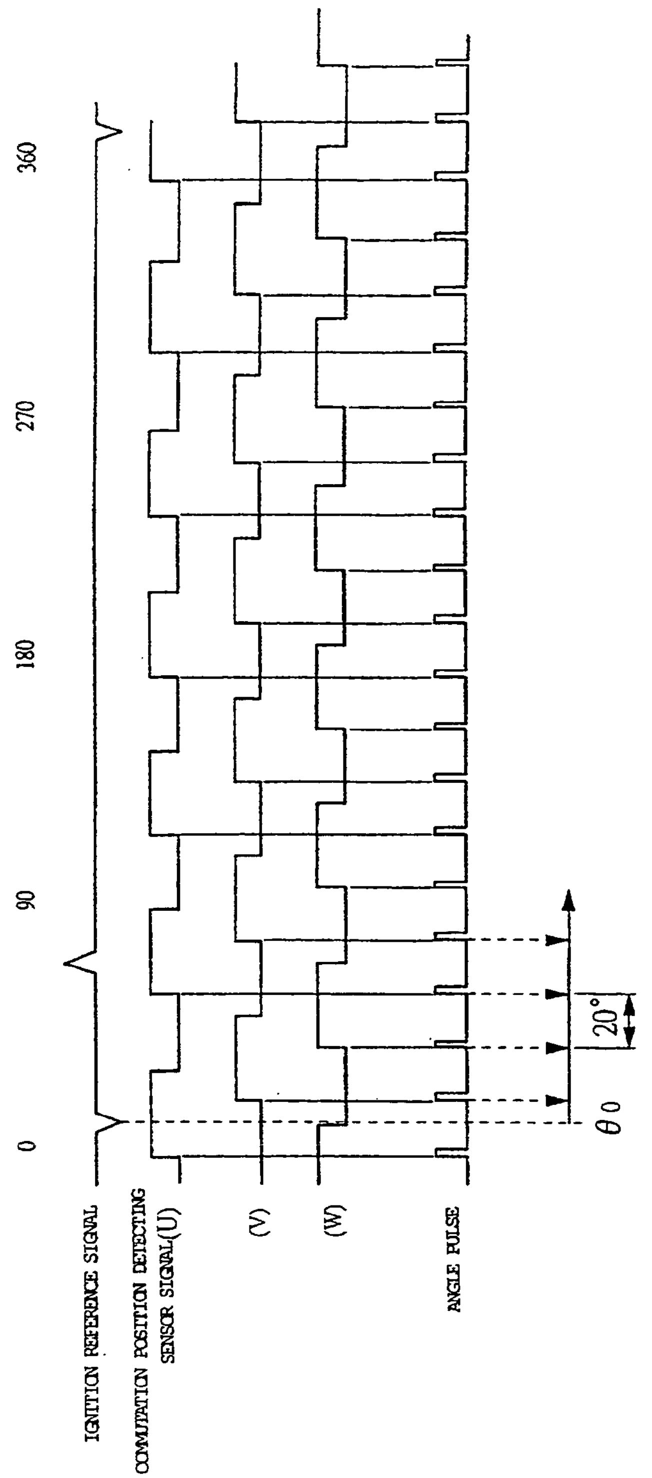

0
90
180
270
360
IGNITION REFERENCE SIGNAL
COMMUTATION POSITION DETECTING SENSOR SIGNAL(U)
(V)
(W)
ANGLE PULSE
20°
θ0

FIG. 15

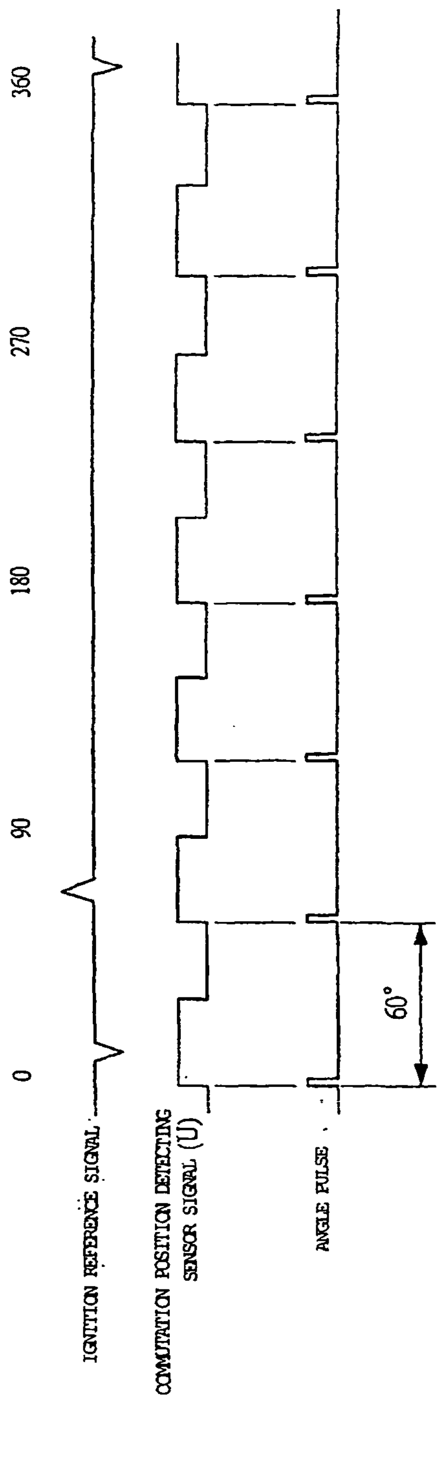

0
90
180
270
360
IGNITION REFERENCE SIGNAL
COMMUTATION POSITION DETECTING SENSOR SIGNAL (U)
ANGLE PULSE
60°

FIG. 16

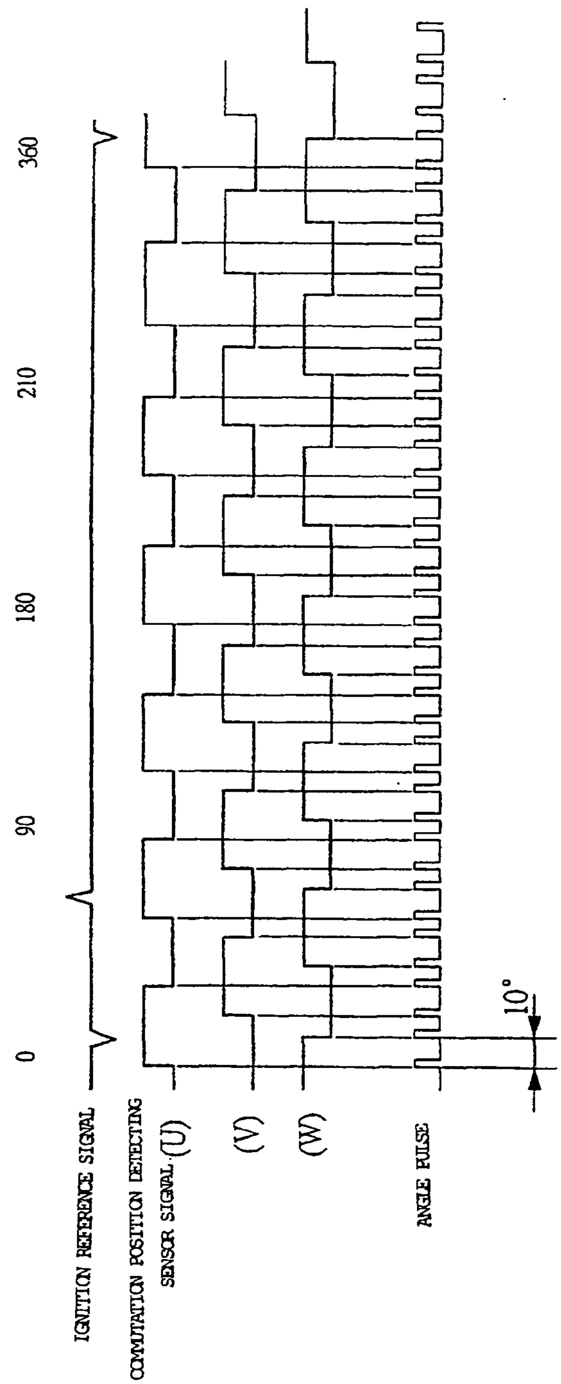
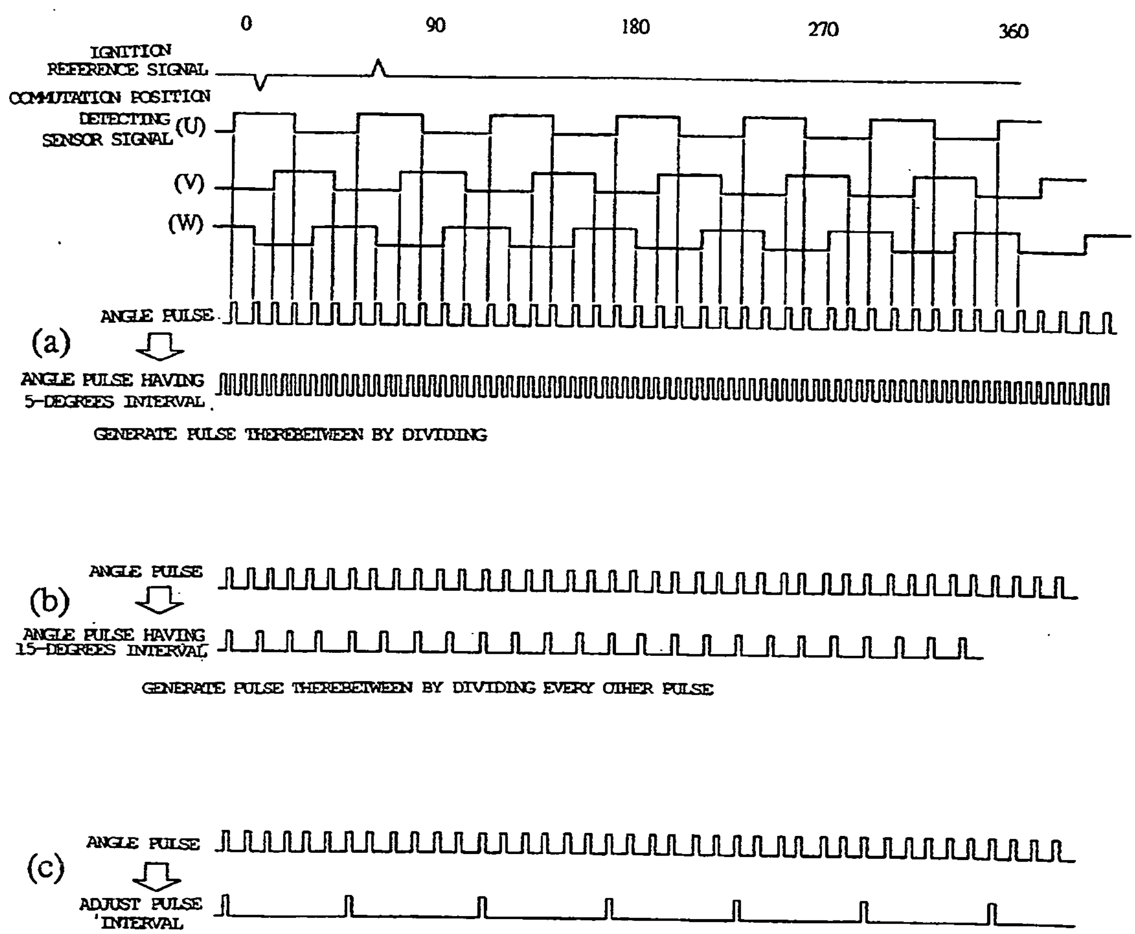

0
90
180
210
360
IGNITION REFERENCE SIGNAL
COMMUTATION POSITION DETECTING SENSOR SIGNAL (U)
(V)
(W)
ANGLE PULSE
10°

FIG. 17


0
90
180
270
360
IGNITION REFERENCE SIGNAL
COMMUTATION POSITION DETECTING SENSOR SIGNAL (U)
(V)
(W)
ANGLE PULSE
(a)
ANGLE PULSE HAVING 5-DEGREES INTERVAL
GENERATE PULSE THEREBETWEEN BY DIVIDING
ANGLE PULSE
(b)
ANGLE PULSE HAVING 15-DEGREES INTERVAL
GENERATE PULSE THEREBETWEEN BY DIVIDING EVERY OTHER PULSE
ANGLE PULSE
(c)
ADJUST PULSE INTERVAL

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/08241

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl⁷ F02N11/08, F02D35/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl⁷ F02N11/08, F02D35/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Jitsuyo Shinan Toroku Koho	1996-2001
Kokai Jitsuyo Shinan Koho	1971-2001	Toroku Jitsuyo Shinan Koho	1994-2001

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 2-41689, A (Mazda Motor Corporation), 09 February, 1990 (09.02.90) (Family: none)	1-17
A	JP, 7-71350, A (Denso Corporation), 14 March, 1995 (14.03.95) & US, 5458098, A1 & DE, 4430651, A1	1-17

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February, 2001 (20.02.01)	13 March, 2001 (13.03.01)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)